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ENGINEERING:

An Illustrated Weekly Journal.

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See page 17, July 15 9108

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See Advertisement page 97.

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See Advertisement page 26. 9091

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See Advertisement page 44, July 15. 9089

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See Advt. page 94, July 15
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BOROUGH OF AYLESBURY.

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Tenders are Invited for

SUPPLYING and FIXING FIVE ELECTRIC MOTORS and PUMPS (capable of lifting 70,000 and 50,000 gallons per hour of Effluent, Storm and Tank Water), VALVES, etc., at the Sewage Works, Aylesbury. The Pumps to be of the Centrifugal Type.

Plans and Specification may be seen on application to the undersigned upon payment of £1 1s., which will be returned on receipt of a *bona-fide* Tender and return of all documents

Sealed Tenders endorsed "Tender for Electric Motors and Pumps" together with Drawings to be delivered to my office not later than Twelve o'clock, Noon, on Friday, July 30th, 1921.

Contractors desirous of being shown over the site are requested to make arrangements with the Engineer and Surveyor.

The Council does not bind itself to accept the lowest or any Tender.

WM. HAROLD TAYLOR,
Borough Engineer and Surveyor.

Town Hall, Aylesbury,
July 11th, 1921. R 436

COUNTY BOROUGH OF BELFAST.

ELECTRICITY DEPARTMENT.

The Belfast Corporation invite

Tenders for the Manufacture,

DELIVERY and ERECTION at the New Harbour Power Station, Belfast, of the following PLANT:—

SECTION "M." One 12,500 Kw. Turbo Alternator, with Condensing Plant and Auxiliaries.
" "N." Four Water Tube Boilers, with Superheaters and Forced Draught Fans.
" "O." Four Fuel Economisers.
" "P." Two Steel Chimneys with four Electrically Driven Suction Draught Fans.
" "Q." One Electrically Driven Centrifugal Pump, capacity 18,000 g.p.m.

Specifications and other particulars may be obtained on application either to Messrs. PREECE, CARDEW & RIDER, 8, Queen Anne's Gate, Westminster, S.W. 1, or to Mr. T. W. BLOXAM, City Electrical Engineer, Belfast.

Tenders, upon the printed forms and sealed in envelopes endorsed, "Tender for Plant, New Harbour Power Station," must be lodged in the Town Clerk's Office, City Hall, Belfast, not later than Ten a.m., on Monday, the 22nd August, 1921.

The lowest or any Tender will not necessarily be accepted.

An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

R. MEYER,
Town Clerk. R 504

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND ERECTION OF SEMI-DIESEL ENGINES, CENTRIFUGAL PUMPS AND SHAFTING, AT BARN ELMS, BARNES, SURREY.

The Metropolitan Water Board invite

Tenders for the Supply and

ERECTION of FOUR SEMI-DIESEL ENGINES, each of approximately 35 B.H.P., and FOUR CENTRIFUGAL PUMPS, SHAFTING, PULLEYS, &c., at their Barn Elm Works, Barnes, Surrey.

Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected without payment of fee at the Offices of the Board, Engineer's Department (Room 112), 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Tuesday, 2nd August, 1921. Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £1 1s., which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona fide* tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and Four p.m. (Saturdays Ten a.m. and Twelve Noon), Thursdays excepted.

Tenders enclosed in sealed envelopes, addressed to "The Clerk and Solicitor, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1" and endorsed "Tender for Machinery, Barn Elms," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 21st September, 1921.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Offices of the Board, Clerk and Solicitor,
173, Rosebery Avenue, E.C. 1.
19th July, 1921. R 517

Tenders Required for 100,000

FIREBRICKS, 9 in. by 4½ in. by 3 in., sending sample. Tenders to be received not later than August 6th.—JOHN THOMPSON (WOLVERHAMPTON) LIMITED, Engineering Works, Wolverhampton. R 515

COUNTY BOROUGH OF CROYDON.

TO STEEL MANUFACTURERS AND CONTRACTORS.

NOTICE IS HEREBY GIVEN that the Council are prepared to receive

Tenders for the Supply and

DELIVERY to Russell Hill Reservoir, Woodmansterne Road, South Croydon, of about 214 TONS of STRUCTURAL STEELWORK.

Specification, Conditions and Form of Tender may be obtained on application at the Borough Engineer's Office, Town Hall, Croydon, upon payment of a deposit of One Guinea, which will be returned upon receipt of a *bona-fide* Tender.

Tenders on the prescribed form to be sent to me by Eleven o'clock in the forenoon of TUESDAY, the 16th day of AUGUST, 1921, endorsed "Tender for Steelwork, Russell Hill Reservoir."

Tenders will only be received subject to the terms of the draft contract deposited at my office, and which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

JOHN M. NEWNHAM,
Town Clerk.

Town Hall, Croydon,
15th July, 1921. R 499

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:

No.		Fee for Specification.
1.	Spark Arresters and Sieves ...	2s. 6d.
2.	Drawn Brass Angles, &c. ...	7s. 6d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Spark Arresters and Sieves," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 9th August, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Company's Offices, Secretary.
48, Copthall Avenue, E.C. 2.
London, 21st July, 1921. R 540

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,

are prepared to receive

Tenders for the Supply of:—

ROOFING, STANCHIONS, GIRDERS, &c. (required for New Carriage and Wagon Shops).

Specifications and Forms of Tender may be obtained at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Roofing, &c.," must be left with the undersigned not later than Two p.m. on Wednesday, the 3rd August, 1921.

A charge, which will not be returned, will be made of 20s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
London, S.W. 1.
20th July, 1921. R 553

APPOINTMENTS OPEN.

EAST LONDON COLLEGE (University of London) Mile End, E. 1.

Required, a Lecturer in Civil

ENGINEERING. Initial Salary from £500 to £550, according to qualifications. Particulars on application to the REGISTRAR. R 479

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

Applications are Invited

before August 1st for an ASSISTANT LECTURESHIP in the Department of Civil Engineering. Salary £300 to £350 according to qualifications. Practical experience essential. Particulars may be obtained from the PROFESSOR of CIVIL ENGINEERING, at the College. R 468

THE UNIVERSITY OF SHEFFIELD.

FACULTY OF ENGINEERING.

Applications are Invited for

the POST of ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

Salary £400 per annum, including evening work during Winter Session. Candidates holding a University Degree with Honours in Mechanical Science preferred.

Applications, stating particulars of training and experience, accompanied by three testimonials, should be sent not later than August 20th to the undersigned.

W. M. GIBBONS,
Registrar. R 520

THE QUEEN'S UNIVERSITY OF BELFAST.

PROFESSORSHIP OF GEOLOGY.

Applications are Invited for

the PROFESSORSHIP OF GEOLOGY in Queen's University, which becomes vacant on the 30th September. Particulars of the appointment may be had from

J. M. FINNEGAN,
Secretary. R 533

CITY & GUILDS (ENGINEERING) COLLEGE.

There are Two Vacancies in

the Mechanical Engineering Department for DEMONSTRATORS in Engineering Science. Salary £300.—Apply, in the first instance, to Professor W. E. DALBY, F.R.S., City and Guilds (Engineering) College, Exhibition Road, London, S.W. 7, before July 26th. R 509

MINISTRY OF EDUCATION, EGYPT.

DEPARTMENT OF TECHNICAL, INDUSTRIAL AND COMMERCIAL EDUCATION, CAIRO.

Applications are Invited for

the POST of PRINCIPAL of the SCHOOL OF ENGINEERING, Giza (a Higher College), which will be vacant from October 1st next.

High academic and professional qualifications, together with responsible University and professional experience are desired.

The salary proposed is £E. 1200 to £E. 1440 with free residence, but the Selection Committee will be prepared to recommend an increase on this for an exceptionally qualified and experienced candidate.

Before making formal application, intending applicants should obtain from G. BLLIOT, Esq., Director, Egyptian Educational Mission, 28, Victoria Street, London, S.W. 1, a copy of the Note giving further particulars of the position together with instructions for applying.

July 1st, 1921. R 497

ROYAL NAVY.

Applications are Invited

for APPOINTMENTS as INSTRUCTOR LIEUTENANTS in the Royal Navy.

Candidates must be under 30 years of age, have had a University Training, and have taken an Honours Degree in Mathematics, Science or Engineering.

Present rates of pay are from £365 per annum on entry to a maximum of £949 per annum as Instructor Commander. Promotion by selection, to Instructor Captain is also open, with a maximum of £1,277 per annum.

Retired pay, to Officers over 40 years of age, after 12 years' service, ranges from £300 per annum for an Instructor Lieutenant to a maximum of £900 for an Instructor Captain, according to length of service. Service pension is also allowed to Officers if invalided before becoming eligible for retired pay.

Service Victualling, cabin accommodation and servant are provided.

In cases where it is not possible to provide these the following allowances are paid in lieu:—

VICTUALLING ALLOWANCE	£80 per annum.
LODGING ALLOWANCE	£30 to £100 per annum according to Rank.
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For further particulars apply in the first instance to:—

THE SECRETARY OF THE ADMIRALTY,
Whitehall, S.W.1 R 444

Research Department,
ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH JUNIOR ASSISTANT.

Required, One Metal-

LURGIST; should be graduate who has received a University training in Metallurgy.

Initial salary £160 and bonus. (Total emoluments at present £362 19s. 0d.).

Annual leave, 24 days.

Applications in writing, accompanied by copies of not more than three testimonials should be made to the CHIEF SUPERINTENDENT, Research Department, Royal Arsenal, Woolwich, S.E. 18, from whom the conditions of Employment may be obtained. R 516

BOMBAY, BARODA & CENTRAL INDIA RAILWAY.

TWO ASSISTANT ENGINEERS.

The Directors are prepared to receive

Applicatfons (by Letter Only)

from duly qualified Candidates for APPOINTMENT on the above Railway in the Way and Works Department. Candidates must be active, of good physique, with a thorough knowledge of instrument work and well trained in ordinary engineering knowledge. They must have been trained in a recognised Engineering College and have passed the Associate Membership Examination of the Institution of Civil Engineers, or hold an exempting degree. Preference will be given to those who have had practical experience of not less than a year with a British or Colonial Railway on construction or open line maintenance, or with the Royal Engineers on Field Service.

TERMS.—Three years' agreement in the first instance with a salary commencing at Rs. 550 to Rs. 700 according to age and qualifications, and rising according to the Company's Rules. First class free passage to India (salary commences from date of sailing for India), and home again on termination of services.

AGE.—Must not exceed 25 years.

Applicants must give a full record of their career in chronological order, with dates, giving details of their general and technical education, training and subsequent experience with copies only of any testimonials, certificates, etc., which they may have in their possession. Details of service with H.M. Forces should be given.

Full particulars stating age, whether married or single, etc., as set out above, should be sent to the undersigned not later than 6th August, 1921.

Officers who have suffered disablement through wounds, provided their disability will not interfere with the proper performance of their duties, will be eligible, but selected candidates will only be finally appointed subject to their passing a strict medical examination by the Company's Consulting Physician.

S. G. S. YOUNG,
Offices: Secretary.
The White Mansion,
91, Petty France (late York St.),
Westminster, S.W. 1. R 519

The DIRECTORS of an AEROPLANE MANUFACTURING COMPANY are prepared to receive

Applications for the Post of

CHIEF of the DESIGN and DRAWING OFFICE. Applicants must have successfully filled a similar position and have had good experience. All applications will be treated with the strictest confidence and must give full details of experience, age, salary required and earliest date new post could be taken up.—Write BOX F.A.E., c/o DAVIES AND CO., 95, Bishopsgate, E.C. 2. R 511

Applications are In-

VITED for the POST of ASSISTANT to the Metallurgical Inspector at Jamshedpur, Bihar and Orissa, India. The appointment will be for three years in the first instance on a salary of Rs. 475 a month rising to Rs. 575 a month, with a share of fees up to a maximum of one-third of salary and a prospect of further annual increase of salary if the appointment is continued. If confirmed in the appointment, the incumbent would either be placed on a pensionable footing or be admitted to a provident fund to the benefits of which the State would contribute. The duties consist chiefly of the inspection under various specifications of rails, constructural Steel, etc. Candidates should possess a University degree in metallurgy, or be able to give evidence of an equivalent training. It is desirable that the officer appointed should be unmarried and have had not less than 2 years' experience in steel works. He would be required to proceed to India in the Autumn.

Applications should be addressed to the UNDER SECRETARY OF STATE FOR INDIA, Industries and Overseas Department, India Office, London, S.W. 1, not later than 8th August, and should contain full information as to age, qualifications, etc. The names and addresses of three references should also be given. R 477

Junior Technical

ASSISTANT REQUIRED in Physics and Instruments Experimental Department at Farnborough. Candidates should be up to the standard required for Hons. Degree in Physics or Engineering Science and have experience in Scientific Instrument design, development and construction. Should be willing to fly (as passenger) and must be medically fit for such. Salary £175–£15–£325 plus Civil Service bonus, amounting probably to about £340 inclusive. The post is pensionable under the Federated Universities Superannuation Scheme. Applications marked "Instruments" will be considered only from ex-service men and should be sent to the SECRETARY, JOINT SUBSTITUTION BOARD, Montagu House, Whitehall, S.W. 1, not later than the 29th July, giving full statement of qualifications and experience. Only those candidates whose qualifications appear prima facie suitable will be interviewed. R 496

Technical Assistant

(Grade 1) REQUIRED in Aerodynamics Experimental Department at Farnborough. Candidates should be up to the standard required for a 2nd Class Hons. Degree in Engineering Science, should have experience in aerodynamic experimental work and in an engineering workshop. Should be willing to fly (as passenger) and medically fit for such. Salary £350–£20–£450 plus Civil Service bonus, amounting probably to about £575 inclusive. Post is pensionable under the Federated Universities Superannuation Scheme. Applications marked "Aerodynamics" will be considered only from ex-service men and should be sent to the SECRETARY, JOINT SUBSTITUTION BOARD, Montagu House, Whitehall, S.W. 1, not later than the 29th July, giving full statement of qualifications and experience. Only those candidates whose qualifications appear prima facie suitable will be interviewed. R 498

Wanted, Works' Manager for

Constructional Steel Work. One possessing extensive experience in all kinds of constructional steel work, bridges, steel pipes, etc. Must have intimate knowledge of costs and production.—Address, stating age, detailed experience and salary required, R 495, Offices of ENGINEERING.

Wanted, for small Yorkshire

Engineering Works, a YOUNG MAN, who has had shop and drawing office experience, to train for position as Works Manager in Repetition work. Small salary, but excellent prospects. Should be well educated and a public school man. Write, stating age, qualifications and experience.—Address, R 493, Offices of ENGINEERING.

Wanted, Estimator and Rate

FIXER, experienced in Smith and Machine Shopwork for an important Engineering Works in the North of England. Good salary for fully qualified man.—Address, R 523, Offices of ENGINEERING.

Secretary-Director Required

for old-established well-known Limited Company, London, engaged in Manufactures. Preference to one with some Engineering knowledge. Investment £1800. Salary £600 p.a., plus dividends. Open to Solicitors' and Accountants' investigation.—Write, BOX 450, SELLS, 167, Fleet St., E.C. 4. R 510

Wanted, for Cement Plant,

North of England, a Few CEMENT MILLERS for Wet and Dry Grinding, also BURNERS. Good men only required. Give full particulars, age, experience, etc.—Address, R 490, Offices of ENGINEERING.

Engineer Wanted, Midland

area, to take charge of moderate size works producing high-class speciality (not mass production). Good technical qualifications and engineering experience. Age about 30-35. Salary £400 per annum with prospects.—Address, R 386, Offices of ENGINEERING.

Waterpower.—Commercial

ENGINEER REQUIRED; one who has had experience in calling on waterpower users throughout the country and generally advising them on the best type of plant to install, and taking measurements, etc.

When applying, state experience, age and salary required.—Address, R 491 Offices of ENGINEERING.

Wanted, a Thoroughly Good

FITTER and ERECTOR for traction engine repairs in small country shop. Must have had previous experience with steam engines and must be non-society. Wages £4 per week. Permanent work to suitable man.—Address, R 501, Offices of ENGINEERING.

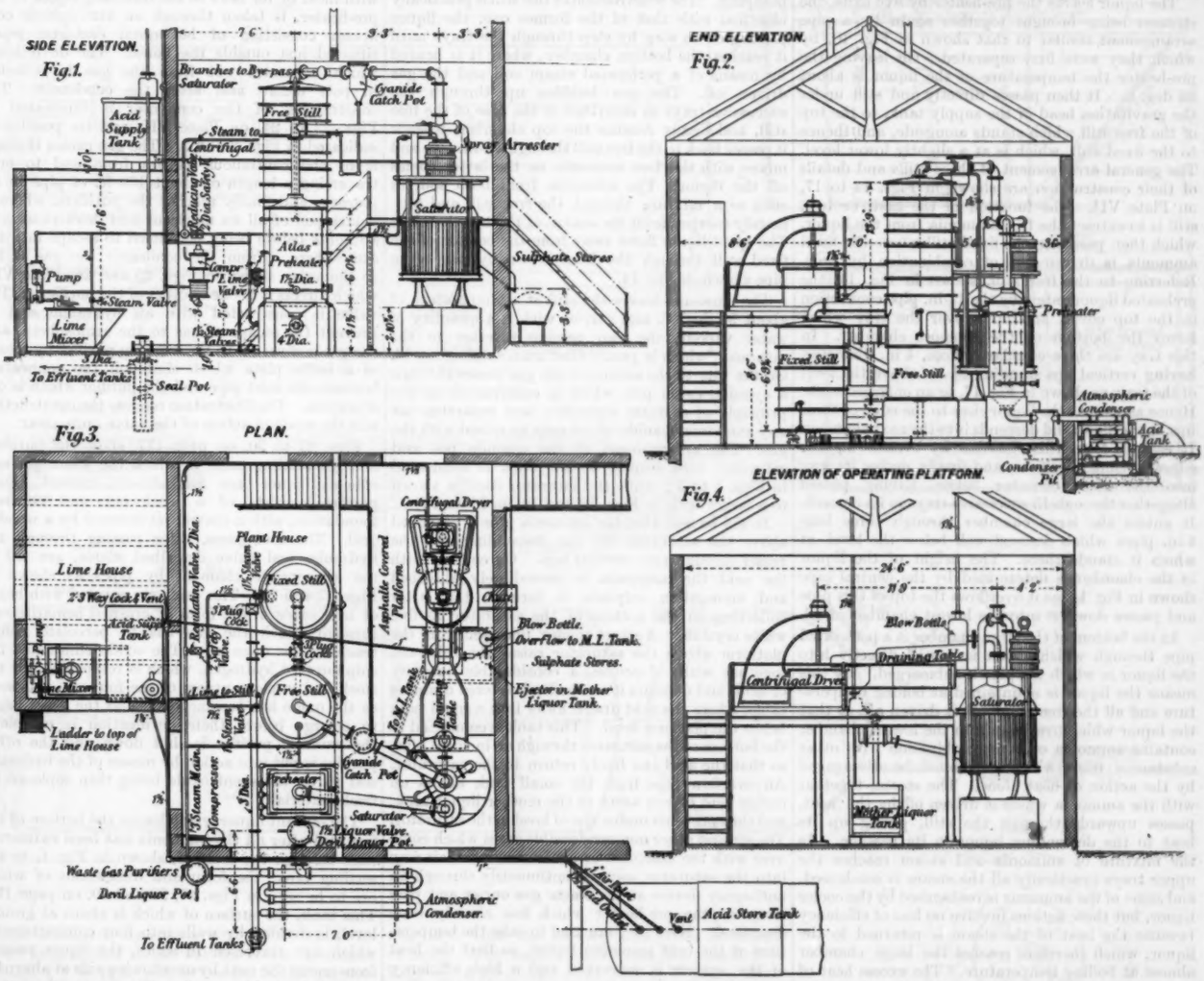
SULPHATE OF AMMONIA PLANT AT LEAMINGTON GAS WORKS.

COAL is the chief British source from which the ammonia, so essential to our agricultural and other industries can be obtained, and it is likely to remain so, at any rate until some method for the fixation of atmospheric nitrogen which is commercially practicable in this country, shall have been devised. When coal is distilled, either in a gas works or a coke-oven plant, the ammonia passes off with the gases, from which its recovery in the form of sulphate has long been a standard commercial process. The recovery of ammonia is an entirely beneficial operation, for it is of no use whatever in the gas, and it is far too valuable a by-product to be allowed to go to waste.

In the ordinary method of making coal gas, the volatile portions of the coal in the retorts pass away through the ascension pipes which terminate in the "hydraulic main," a closed trough containing water which lies along the top of the retort bench. The ends of the ascension pipes are turned over and dip a few inches beneath the surface of the water in the main, so that the liquid both seals the pipes and condenses much of the tarry and other vapour in the gas. The water becomes "ammoniacal liquor" which is run off periodically from the hydraulic main, and when freed from tar provides a source of ammonia. The gas itself, however, carries away a good deal of ammonia, which is extracted by washing. The gas passes upwards through a shower of water in tower scrubbers, and gives up its ammonia to the descending water. The water is continuously pumped back to the top of the towers, and by repeatedly washing fresh volumes of gas it comes to contain a considerable quantity of ammonia. Finally it passes away as "weak liquor" in distinction to the "strong liquor" from the hydraulic main. These liquors are finally mixed, and the resultant, containing on an average 1·3 per cent. of ammonia, is the raw material from which the ammonia is abstracted in the form of sulphate. The ammonia in the liquor exists both in the free and fixed states, the free ammonia being readily driven off by the application of heat, and the fixed ammonia being liberated by the addition of lime to the hot liquid. By bringing the released ammonia into contact under proper conditions with sulphuric acid, chemical combination takes place and sulphate of ammonia is formed. This is a crystalline salt, and is separated from the mother liquor by the centrifugal method, forming the sulphate of ammonia of commerce.

Figs. 1 to 4, annexed, show the general arrangement of a compact and efficient sulphate of ammonia plant, designed and constructed by Messrs. Thomas Piggott and Co., Limited, Spring Hill, Birmingham, for the Leamington Priors Gas Company, Limited. The plant, which is quite self-contained, is housed in a neat brick building in the gas works yard, and is capable of a daily output of from 3 tons to 4 tons of sulphate of ammonia, the only staff required for its complete operation being two men. It will extract the ammonia from 56 tons of liquor per day, this quantity being somewhat more than the Leamington Gas Works will produce, and the balance therefore being brought to the works in barges from other gas works not possessing facilities for dealing with their own liquor. The compactness of the plant is shown by the fact that excluding the lime house and sulphate store, a room 20 ft. wide by 24 ft. 6 in. long and 18 ft. high will accommodate the whole of the apparatus, except a small atmospheric condenser, which is naturally put outside. The acid store tank is also placed out of doors, and the acid supply tank is situated on the roof of the lime-house, which is lower than the rest of the building.

The ammoniacal liquor is delivered continuously from an overhead tank, not shown in the drawings, to the pre-heater, the position of which can be seen in Figs. 1, 2 and 3. The construction of the pre-heater, which is of Messrs. Piggott's "Atlas" type, is shown in Figs. 5 to 10, Plate VII, the details being illustrated to a larger scale in Figs. 11 to 13 on the same Plate. The body of the pre-heater is a rectangular cast-iron chamber, through which the waste gas from the saturator passes in a downward direction, the inlet and outlet of the gas being respectively in the centres of the coned top and bottom of the casing. The temperature of the gas at inlet is about 92 deg. C. and at outlet about 20 to 25 deg. C. The liquor, which is at atmospheric temperature and contains about 1·3 per cent. of ammonia, passes to the pre-heater through the 1¼-in. cock shown in Figs. 9 and 10, and is then divided into five separate streams, three of which enter the pre-heater on one side and two on the other. Each stream traverses the pre-heater, enclosed in a horizontal cast-iron U-pipe, which returns it to a point close beside that at which it entered. Thence it is led by means of an external cast-iron bend to the entrance of the horizontal U-pipe immediately above, and so on till it has made a sufficient number of horizontal double passes to bring it to the top of the pre-heater. The arrangement of the pipes is well shown in



Figs. 5 to 7, while Figs. 11 to 13 make clear the way in which the various tubes are held. It will be noted that the free ends of each horizontal tube are united by a common flange by which the element is secured to the casing and which forms a cover for the hole through which the tube is inserted. The weight of the other end of the element is supported by a set-screw resting on a little bracket in the manner shown. The design permits any element to be withdrawn if desired with the minimum amount of trouble, and also ensures that the pipe shall not be subjected to any strain, either from its own weight or from its expansion when heated. All joints are external ones and their condition is readily visible.

The liquor leaves the pre-heater by five exits, the streams being brought together again by a pipe arrangement similar to that shown in Fig. 10, by which they were first separated. On leaving the pre-heater the temperature of the liquor is about 88 deg. C. It then passes directly and still under the gravitation head of the supply tank, to the top of the free still which stands alongside, and thence to the fixed still, which is at a slightly lower level. The general arrangement of these stills and details of their construction are shown in Figs. 14 to 17, on Plate VII. The function of the first, or free, still is to extract the free ammonia from the liquor, which then passes to the fixed still where the fixed ammonia is driven out of combination by lime. Referring to the free still, shown in Fig. 14, the preheated liquor enters by the 1½-in. pipe connection in the top cover, and flows over the tray which forms the bottom of the topmost chamber. In this tray are three circular orifices, 4 in. diameter, having vertical lips standing 2⅝ in. above the level of the tray, as shown in Fig. 17, to an enlarged scale. Hence as soon as the liquor rises to the edge of these lips, it overflows and descends into the next chamber. It escapes from this chamber by overflowing the edges of similar orifices, and finally makes its way into the large chamber below, having passed altogether through 13 successive trays in its descent. It enters the large chamber through three long 4-in. pipes which descend well below the level at which it stands there. The height of the liquor in the chamber is determined by the central pipe shown in Fig. 14, as it overflows the top of this pipe and passes down it into the lowest chamber of all.

In the bottom of the large chamber is a perforated pipe through which steam is passed directly into the liquor in which the pipe is submerged. By this means the liquor is maintained at boiling temperature and all the free ammonia is driven off, so that the liquor which overflows into the lowest chamber contains ammonia only in combination with other substances from which it cannot be disengaged by the action of heat alone. The steam, together with the ammonia which is driven off by the heat, passes upwards through the still, giving up its heat to the descending liquor in its passage. As the mixture of ammonia and steam reaches the upper trays practically all the steam is condensed, and some of the ammonia is reabsorbed by the cooler liquor, but these actions involve no loss of efficiency because the heat of the steam is returned to the liquor, which therefore reaches the large chamber almost at boiling temperature. The excess heat of the ammonia vapour is also transferred to the cooler liquor and beneficially employed, while the fact that a certain amount of ammonia is reabsorbed by the liquor has no practical significance because it will be all driven off again, and all the free ammonia must eventually escape from the top of the free still.

In passing upwards through the still, the steam and ammonia rise through the various trays by means of elongated radial ports, of which there are six in each of the trays to be traversed. The shape and position of these ports are shown in Fig. 15, and an enlarged vertical part-section through them is given in Fig. 16. Each port is covered by an inverted bubbling hood with serrated edges which dip well beneath the surface of the liquor in the tray. The vapour therefore can only escape by bubbling through the liquor, and the serrations of the edges of the hoods ensure that the bubbles shall be small and the vapour shall thus be brought intimately into contact with the liquor. Hence the steam will be effectively condensed and the ammonia reduced to the same temperature as that of the incoming liquor.

Returning to the liquor which has given off all its free ammonia and found its way into the lowermost chamber of the free still, this is here mixed with a solution of milk of lime, which is pumped into it by a small steam pump at the lime-mixing tank. The mixture then flows by its gravity head up the sloping 4-in. pipe shown in Figs. 14 and 15 to the topmost chamber of the fixed still, which it enters at the side. The relative position of the two stills is so arranged that the gravity head shall be sufficient to effect the transference of the limed liquor to the fixed still without the need of any pumping. The construction of this still is practically identical with that of the former one, the liquor passing down step by step through the trays until it reaches the bottom chamber, where it is heated by means of a perforated steam coil and the gas driven off. The gas bubbles up through the successive trays as described in the case of the free still, and finally reaches the top chamber, whence it passes back to the free still through a 5-in. pipe and mixes with the free ammonia as the latter comes off the liquor. The ammonia from both sources rises as a mixture through the free still and ultimately escapes from the centre of the top chamber. The spent liquor flows away from the bottom of the fixed still through the 3-in. internally projecting pipe shown in Fig. 14.

The ammonia leaves the still at a temperature of about 94 deg. C. and carries with it a quantity of water vapour, the two passing together to the saturator, which is partly filled with sulphuric acid. On the way to the saturator the gas passes through a cyanide catch pot, which is constructed on the principle of a steam separator, and separates out any ammonia cyanide which may be mixed with the gas. The arrangement of the cyanide pot and saturator with respect to the stills is illustrated in Figs. 1 to 3; while the saturator itself is shown to a larger scale in Figs. 18 and 19, on Plate VII.

It will be seen that the ammonia pipe is branched above the saturator, the gas descending into the vessel through two vertical legs. On contact with the acid the ammonia is immediately absorbed and ammonium sulphate is formed, the latter collecting on the bottom of the saturator as fine white crystals. A steam ejector, operated from the platform above the saturator raises the sulphate, together with, of course, a considerable quantity of acid, and deposits it on the lead-covered draining table, where the acid drains away into a small tank below the platform level. This tank is connected to the bottom of the saturator through an inclined pipe, so that the acid can freely return to the saturator. An overflow pipe from the small tank allows an excess acid to run away to the mother liquor tank, and thus prevents undue rise of level in the saturator. The air and other non-condensible gases which come over with the ammonia or otherwise find their way into the saturator, escape continuously through an anti-spray device at the waste gas outlet and pass away to the pre-heater which has already been described. Here they are used to raise the temperature of the cold incoming liquor, so that the heat of the system is conserved and a high efficiency secured.

The sulphate crystals from which most of the acid has been drained are allowed to collect on the draining table until a mass weighing 2 cwt. or 3 cwt. has accumulated, when they are scraped along the lead-lined trough by the attendant and pass down the hinged shoot at the end into a centrifugal drier. This machine, which is illustrated in Figs. 20 and 21, is essentially a copper basket which can be rotated at a high speed inside a lead-lined case. It is driven by a 5-in. by 7-in. steam engine neatly arranged between the side frames of the machine in the manner shown in the illustrations. The copper basket runs at 1,200 r.p.m. and the centrifugal force drives off the acid and leaves the crystals retained in the basket by the fine mesh and practically dry. The acid which has been driven off drains back either to the saturator or to the mother liquor tank, and the crystals of sulphate are dumped through a conical valve provided for the purpose in the bottom of the basket. The mother liquor tank which, as we have seen, receives all the drains of acid from various parts of the plant, is fitted with a steam ejector to enable the acid to be returned to the saturator. The tank is lined with chemically pure lead and its position is shown in Fig. 4, page 135. The sulphate of ammonia discharged from the centrifugal machine falls into a shoot, which leads it through the wall into a barrow in the sulphate store, as shown in Figs. 1 and 2. Here it can be wheeled away, loaded into bags or otherwise disposed of, as it is now finished with so far as its preparation is concerned.

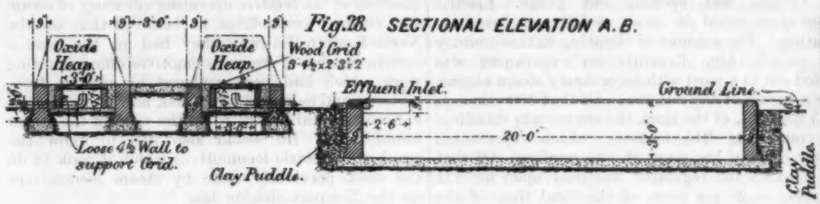
We have now to consider what becomes of the waste gas from the saturator. This, after parting with most of its heat to the incoming liquor in the pre-heater, is taken through an atmospheric condenser consisting of horizontal cast-iron pipes, situated just outside the house. The devil-liquor which separates out from the gas is collected in pots before and after the condenser. The construction of the condenser is illustrated in Figs. 22 to 24, on Plate VII, and its position is indicated in Figs. 2 and 3. The gas passes through it in one continuous stream from end to end, traversing a length of about 160 ft. of pipe in its journey, and finally reaches the purifiers, where it is stripped of all its nauseous and deleterious constituents before being permitted to escape into the atmosphere. From the condenser the gas is led to the valve shown in Figs. 25 and 26, Plate VII, which directs it to one or other of the purifiers. The valve is constructed with an hydraulic seal to prevent the escape of gas to the atmosphere, and the gas is diverted to the working purifier by means of a baffle plate which shuts off the connection between the inlet pipe and the purifier which is out of service. The illustration renders the construction and the mode of action of the valve quite clear.

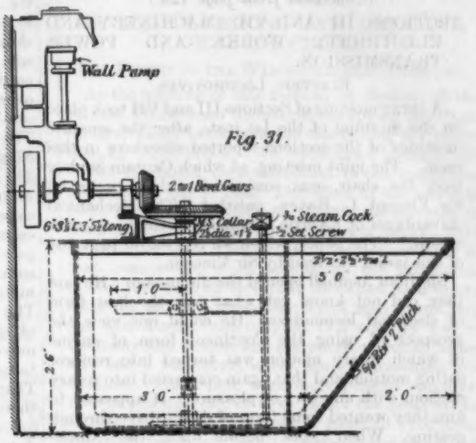
Figs. 27 to 30, on page 137, show the purifiers and the settling tank, in which the waste gas and effluent liquor are respectively treated. Each purifier consists of a brickwork and concrete foundation, with a central pit covered by a wooden grid. The foul gases, after passing through the hydraulic seal valve described above, are led to the appropriate chamber by pipes as shown in Figs. 27 and 28. The grids are covered with heaps of iron oxide in the form of crushed hematite ore, through which the gas has to percolate before reaching the open air. The oxide eliminates the sulphuretted hydrogen, which is responsible for the smell and unpleasantness of the foul gas. As soon as the oxide has become spent and the gases begin to emerge before their purification is complete, the working purifier is shut down and the other purifier is put into action by means of the hydraulic seal valve, the spent oxide being then replaced by fresh material.

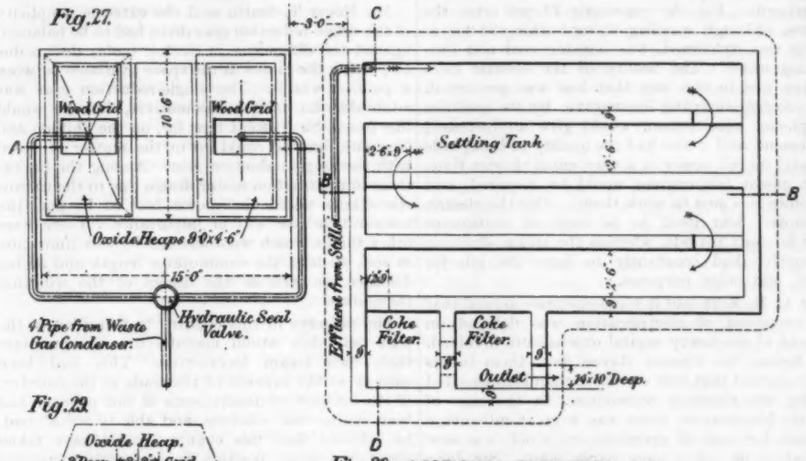
The effluent liquor which leaves the bottom of the free still after all the ammonia has been extracted, runs through the seal-pot, shown in Fig. 1, to the settling tank, the form and dimensions of which are to be seen in Figs. 27, 28 and 30, on page 137. This tank, the surface of which is about at ground level, is divided by walls into four compartments, which are traversed in series, the liquor passing from one to the next by overflowing sills at alternate ends of the dividing walls. The lime settles out in the compartments and the liquor is finally clarified by passing through the two coke filters shown in the illustrations. It is then of a pale sherry colour, quite inoffensive and practically free from smell. It is ultimately disposed of by being run away into the drains.

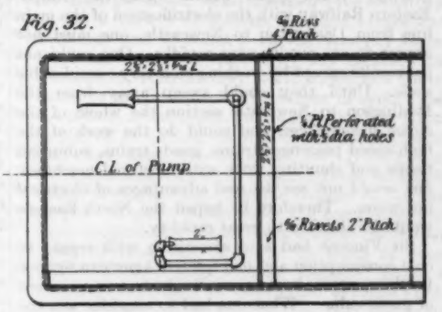
The lime which is required for treating the ammoniacal liquor in the fixed still is stored in the lime-house, shown in Figs. 1 and 3. From the floor of the lime-house measured quantities of lime are shovelled by hand, into the inclined end of the mixer, details of which are given in Figs. 31 and 32, page 137. A perforated plate separates the mixing tank into two parts. The mechanical agitation of the liquid in the rectangular portion washes the lime through the perforations, but the perforated plate retains all stones and foreign bodies in the inclined part from which they can be easily raked out. Mounted on the wall over the mixer is a small engine which drives the agitating paddles by means of bevel gear and also pumps the milk of lime away

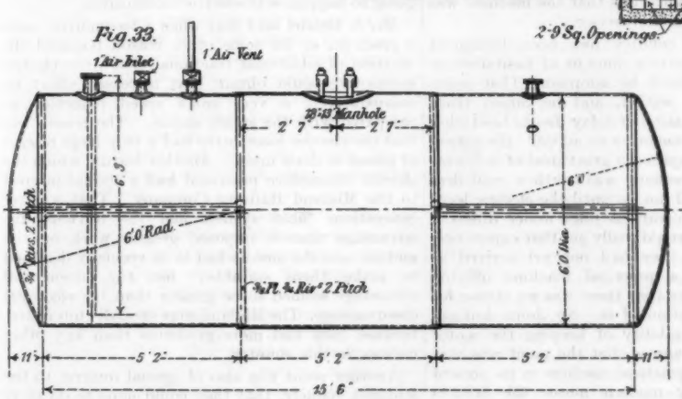
SULPHATE OF AMMONIA PLANT AT LEAMINGTON GAS WORKS.

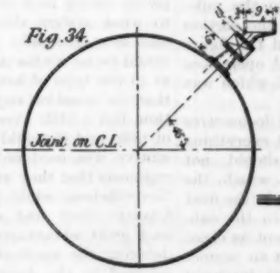


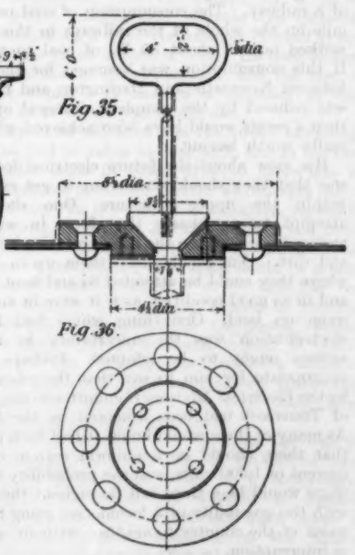












to the still-room, against a head of about 25 ft. Steam is admitted to the bottom of the lime tank through a ¾ in. pipe, and serves the double purpose of heating and agitating the liquid, so that the milk of lime is delivered at the proper temperature to the lime chamber of the still.

The sulphuric acid used in the process is brought up to the gas works by barges which come up the canal alongside the works. These barges are fitted with proper acid tanks and provided with a supply of compressed air which, when led into the tanks through flexible connections, displaces the acid and delivers it through other pipes into the cylindrical storage tank, shown in Figs. 2 and 3 lying partly below ground level in a pit outside the wall of the sulphate-house.

This tank is shown to a larger scale in Figs. 33 and 34, annexed. So efficient is the means provided for unloading the acid, that a 20-ton barge can be moored, emptied and got away in a little over three-quarters of an hour. From the store tank the required amount of acid is raised once a day by means of compressed air to an overhead acid tank, erected on the flat roof of the lime-house, as shown in Fig. 1. It is from this tank that the saturator receives its supply of acid. The tank is of rectangular shape, 6 ft. long by 3 ft. 6 in. wide and 3 ft. 6 in. high. It will hold between 3 tons and 4 tons of 140 deg. Twaddell sulphuric acid, and is lined with lead. The outlet of the acid from the overhead tank is controlled by a conical plug of regulus metal resting in a regulus metal seating, as shown in Figs. 35 and 36.

We have given a very detailed description of the plant, which has been designed and erected throughout by Messrs. Thomas Piggott and Co., Limited, because it exemplifies modern practice in the manufacture of the valuable sulphate of ammonia from gas works liquor. The plant illustrated has now been in operation at Leamington Gas Works for several months and has given complete satisfaction. It requires, as we have already mentioned, the services of two men only who furnish the whole of the labour required. The efficiency of abstraction of ammonia is very high, the plant producing on an average of a three months' run, no less than 26·2 lb. of sulphate of ammonia per ton of coal carbonised. This is highly creditable to Mr. J. R. Marsden, Messrs. Piggott's chemical engineer, who designed the plant, and also to Mr. R. S. Ramsden, Engineer and General Manager to the Leamington Priors Gas Company, for the way in which it is operated.

"LES AILES."—A weekly paper on aerial locomotion entitled *Les Ailes*, is now being published in Paris 17, Boulevard des Batignolles, Paris, 8, at the price of 18 francs annually for abroad. It gives information of a general character on aviation in France and in other countries.

EXHIBITION AND TRIALS OF MOTORS AND TRACTORS BURNING PALM-OIL.—A small exhibition of motors and tractors running on vegetable oils, fuel oil and suction gas from tropical refuse will be held in Brussels at the end of August, in connection with the trials of tractors burning palm-oil, organised by the Belgian Colonial Office. Particulars can be obtained from the Department of Colonial Agriculture, 7, Rue Thérésienne, Brussels.

INSTITUTION OF CIVIL ENGINEERS. ENGINEERING CONFERENCE.

(*Concluded from page* 124.)

SECTIONS III AND VII.—MACHINERY AND ELECTRICITY WORKS AND POWER TRANSMISSION.

ELECTRIC LOCOMOTIVES.

A JOINT meeting of Sections III and VII took place on the morning of the 1st inst., after the separate meetings of the sections reported elsewhere in this issue. The joint meeting, at which Captain Sankey took the chair, was concerned with a paper by Sir Vincent L. Raven, entitled "The Mechanical Advantages of Electric Locomotives compared with Steam." The paper, which we reprint on page 164 of this issue, was read by Sir Vincent.

Sir John Aspinall opened the discussion. He said they did not know yet what was the best form of electrical locomotive. He could not view the prospect of using the Continent form of engine in which rotary motion was turned into reciprocating motion, and that again converted into rotary motion, with any sort of pleasure. It appeared to him they wanted some form of direct drive through gearing. When work began upon the North-Eastern Railway with the electrification of the main line from Darlington to Newcastle, one must not expect to see results very rapidly. One could not get results except by working on a very considerable scale. Until they could sweep away from the Darlington to Newcastle section the whole of the steam locomotives, and could do the work of the high-speed passenger trains, goods trains, suburban trains and shunting work with electrical machines, one would not see the real advantages of electrical operation. Therefore he hoped the North-Eastern would go ahead with great rapidity.

Sir Vincent had said something with regard to coal consumption and had quoted American figures. In this matter, however, individual cases were not of great value. What one had to consider was the average consumption over the whole operation of a railway. The consumption of coal per engine mile on the whole of the railways in this country worked out at about 55 lb. of coal to the mile. If this consumption was assumed for the section between Newcastle and Darlington and the figure was reduced by the complete electrical operation, then a result would have been achieved which was really worth having.

His view about the future electrical locomotive was that they should endeavour to get everything within the upper structure. One should not attempt to perpetuate that form in which the motors were down on the bogey rotating in the dust and dirt. One should keep them up in the cab, where they could be attended to and kept as clean and in as good condition as if it were in an engine-room on land. One thing which had hindered electrification was the uncertainty as to what system ought to be adopted. Perhaps it was appropriate for him to say that the advice given by the Electrical Advisory Committee to the Ministry of Transport had been accepted by the Minister. As many of them would know, it had been proposed that there should be a uniform system of direct current of 1,500 volts, and the probability was that there would be a third rail throughout the country with the possibility of a locomotive going from one point of the country to another without any kind of interruption.

Sir Philip Nash said the present time was more suitable to the extension of steam as a method of operation than electrification. None the less, the advantages in the economies of the electric locomotive were very striking, and he could not imagine that railways could ignore their possibilities. To-day on the railways every attempt was being made to effect economies and secure more efficient working. The electric locomotive gave opportunities in those two important directions which could not be ignored. At the same time he was one of those who believed that the wholesale electrification of railways was neither desirable nor practicable.

One of the greatest advantages of the electric locomotive was that it was possible to obtain a greater tractive effort, with the same loading gauge and with the same axle load, than was possible with a steam locomotive. When the operating man was crying loudly for bigger loads, that was important since it cut out the necessity of strengthening bridges and opening out gauge. Electric locomotives could be most usefully employed on shunting. The amount of shunting in this country was usually big. Recently an experiment was carried out in a yard with an ordinary steam engine, over a period of 435 minutes. Of that 190 minutes, or 43 per cent. of the time, the engine was standing. The remaining 245 minutes, which represented 57 per cent. of the time, it was moving. Of that 245 minutes the regulator was only open for 121 minutes, or 28 per cent. of the total time of the experiment. For the remaining 72 per cent. the engine, although standing doing nothing so far as power was concerned, was burning coal and consuming water. The beauty of the electric locomotive was in the way that loss was prevented. The electric shunting locomotive, by its qualities of quicker acceleration, would give an increased movement, and it also had the quality of being able to exert its full power in a very much shorter time. That meant less engines would be required, and therefore less men to work them. Also the electric locomotive lent itself to be kept on continuous duty for long periods, whereas the steam shunting locomotive had constantly to leave its job for water, and other purposes.

Mr. C. H. Merz said it was sometimes argued that the extension of electrification was delayed on account of the heavy capital expenditure involved. The figures Sir Vincent Raven gave them in his paper showed that this was more than compensated for by the resulting economies. In the case of electric locomotives there was a great advantage in their low cost of maintenance, which was now proved to be not a mere paper point. Sir John Aspinall had called attention to the possibility of running locomotives over long distances on this account, and a great advantage, apart from the actual saving in repairs, which one got from this low cost of maintenance, was that the machine was continuously available for service.

Progress in this country had been hampered partly owing to a certain amount of hesitation as to what system should be adopted. That point was now generally settled, and he hoped there would be no continuation of delay due to hesitation as to the type of locomotive to adopt. He agreed that the question required a great deal of deliberation, but a little experience was worth a great deal of talk, and it would not be until the electric locomotive was used on various lines under different engineers that they would really get that experience. Nevertheless, while they had not yet arrived at finality, they had a practical machine offering such great advantages that there was no excuse for delaying the application of it. Sir John Aspinall referred to the desirability of keeping the motor upstairs. He quite agreed, but the point was that it made a perfectly practical machine in its present position. With any modern motor the failures were practically nil, and if this was the case when it was put in what Sir John Aspinall considered a very bad position, why not go on with what they had got, and consider that good enough for the purpose of gaining further experience.

Sir Philip Dawson said they were, in the case of the electric locomotive, in the position they were thirty years ago in connection with the ordinary direct-current motor, when every designer of motors had a totally different type of motor to offer. There were not only the main types which had been referred to by Sir Vincent Raven, but there were many sub-divisions of those main types which were in use in various parts of the world, but unfortunately in insufficient numbers to enable any really useful comparison to be made between the different types. He could not see why those points which had presented difficulties to the steam locomotive engineer, of the transformation of reciprocating movement into the rotating movement, should be introduced in connection with electric traction. It was, perhaps, difficult to appreciate the reason which had led mechanical engineers of undoubted ability, such as the Swiss and Swedish were, to introduce the connecting rod system, which they had done on the Swedish and on the Swiss State Railways. No doubt the experience gained there would be helpful to them, but for the moment they could not draw any conclusion from it. On the question of the relative operating efficiency of steam and electric locomotives, he believed that on the North-Eastern Railway they had in the past a certain number of steam locomotives doing shunting work which had been replaced by electric locomotives, and he would like to ask how many electric locomotives did it take to do the work of the steam locomotives. He would also like to know the number of electric locomotives which it took to do the work previously done by steam locomotives on the Newport-Shildon line.

Mr. Roger T. Smith said the extreme simplicity of the single-reduction gear drive had to be balanced against the difficulties in electric motor design due to putting the motor in the space available between a pair of wheels. The single-reduction gear was admirable for freight locomotives, but he would like to ask Sir Vincent how far, on the Shildon and Newport line, he could go in the matter of speed with the single-reduction gear. Among the limitations to the traction motor design due to the narrow space into which the motor had to be got, the temperature rise was of importance. There were other things which were affected by this limitation in size, such as the commutator length and arcing distance, as well as the design of the windings themselves.

The railways in this country had decided in the past that they would manufacture and maintain their own steam locomotives. This had been entirely at the expense of the trade in the country. If the locomotive departments of this country had been commercial concerns, and able to sell abroad, he believed that this country would have taken about the same position in locomotive building that it had taken in shipping. There was so small a home market for the commercial maker of locomotives that his foreign market was also restricted; and he hoped the same thing was not going to happen with electric locomotives.

Mr. J. Dalziel said that when a locomotive made a gradient, or for some other reason required the exertion of additional tractional effort, the electric locomotive could obtain that increased effort by comparatively a very small speed reduction as compared with the steam engine. The reason was that the electric locomotive had a very large reserve of power to draw upon. Another feature which the electric locomotive possessed had a special interest to the Midland Railway Company. That was regeneration. That system had the obvious disadvantage that it imposed greater work on the motors, and the motors had to be specially designed to make them suitable; but the mechanical advantage seemed to be greater than the electrical disadvantage. The Midland were specially interested, because they had more gradients than any other railway in this country.

Another point was also of special interest to the Midland, namely, that they could hope to do more with the electric locomotive, by reason of the flexibility of its design and the power it gave to the designer to spread the weight, as compared with the weight of the steam locomotive. They could run an electric locomotive of a weight which in a steam locomotive would be prohibitive, because of the concentrated load if would impose on the track. Such an electric locomotive would be considerably more powerful than the corresponding steam one. There could be no question that the quill type of electric locomotive was that which best met the problem of the high-speed electric locomotive. The quill type utilised the space available between the wheel flanges quite as fully as would ever be necessary for locomotives such as were required in this country. He thought that this type also made the centre of gravity sufficiently high, perhaps not as high as might be desirable but sufficiently high.

The New York central armature type of engine he was not so sure about. He thought it involved too many axles, and presented difficulties in connection with the spacing of the axles and the framing of the engine. Also the wheels seemed too small for good driving, and the centre of gravity was distinctly too low. The rod locomotive seemed

to him an inversion of progress. Its advantage was that it put, as Sir John Aspinall said, the motors upstairs, and made them more accessible, and raised the centre of gravity, but it had the disadvantage of transferring reciprocating motion to rotating motion and back again. There was no doubt this type of locomotive could be made to operate, but the rods tended to lock each other, and to impose heavy stresses, which were bound to be a disadvantage both as regards maintenance and consumption.

Mr. H. N. Gresley wished to say a few words from the point of view of the steam locomotive. Two principal points which the author had touched upon were fuel consumption and cost of maintenance. On fuel consumption the author based his figures on pounds of fuel per brake horse-power hour. He thought it was simpler to take the actual work put into the draw-bar. It was claimed for the electric engines that a consumption of something like 100 lb. of fuel per 1,000 ton-miles was good practice. In connection with the comparisons which had been made in America and which were quoted by Sir Vincent, tests were also made of the Mallet type of engine, and it was found that the fuel consumption was as low as 82 lb. per 1,000 ton-miles. That was on the Santa Fé Railway. There were also other experiments on the New York Central which gave the fuel consumption in pounds per draw-bar horse-power, and the figures were 2·6 lb. for steam, and 2·5 lb. for electric. In England the best practice in most modern engines had obtained a consumption of 100 lb. to 110 lb. per 1,000 ton-miles, on express passenger trains. During the coal strike, on the Great Northern they had been running express passenger trains at an average speed of 50 miles an hour with one engine. The weight of the train was over 600 tons, and the fuel consumption had come out to less than 110 lb. per 1,000 ton-miles.

With regard to the cost of maintenance, it was stated that the cost of maintenance would be one-third in the case of electric as against steam. He had no doubt this was correct, but that was the cost of the maintenance of the locomotive. In dealing with a steam locomotive one had the entire thing, the boiler and everything else. But in dealing with the electric locomotive one had to take into consideration the track maintenance, the cost of maintaining the power station, the cost of the sub-stations, and all the other incidentals to electric traction.

Sir Henry Fowler was perfectly certain that, as soon as the financial conditions permitted, they would have to have electrification to a very large extent upon their railways. The reasons were perfectly clear. The strength of the bridges and the size of the over-structures were the present great difficulties holding up increased loads, and there was no doubt they would be able to get with the electric locomotive the weights needed with, comparatively speaking, small improvements. With the electric locomotive one would get greater overall economies than it was possible for them to get working as hard and working as ingeniously as Mr. Gresley and some others were working with regard to the ordinary locomotive. On the railway of which he had the honour to be a servant, they had as much grate area as they could get, but they had not as much as they would like to have for the burning of their coal. Such difficulties would not occur if they could make their power in a central station. There were disadvantages with electrification, however. With a steam locomotive, if one had a casualty some few persons were delayed for a little time. In the case of the electric system, if one had a casualty at the power station or on the line, it might mean tying up a considerable portion of the system to a very large extent.

Mr. F. W. Carter said that Sir Vincent, among the advantages of the electric locomotive, put its facilities for being driven from either end. That was quite a distinct advantage, but he was doubtful whether a perfectly symmetrical locomotive could be made which fulfilled this condition. Some had been made in two units (of the Atlantic type or the Pacific type) put back to back. It seemed to him the forward unit might be running quite nicely but the one which was driven backwards might be trying all the time to get off the track. The satisfactory locomotive from the running point of view was the one in which the natural tendency of the locomotive was to keep its alignment without using the flanges of the wheels as a primary means of keeping it on. He was doubtful whether the perfectly symmetrical type would do that.

Colonel Lee asked, was there any steam locomotive that could stand more than a third of its time on actual work in the 24 hours? Till the steam locomotive was made to work to approximately the conditions which prevailed in the electric system, by which one could run the electric gear for 10 days without any attention whatever, he thought that the advantages were all in favour of the electric engine. He would like to mention, on behalf of the steam locomotive, that there was a new locomotive being built at Messrs. Armstrong's works which was fitted with a turbine and an air-cooled condenser. It would be on trial in a very short time.

Sir Vincent Raven, replying to the discussion, said what had led him to believe in the electric locomotive was purely a question of finance. The question of labour was one of the utmost importance at the present time. If railways and other industrial concerns in this country were going to see their way through the very serious problems which they were faced with, they would have to lay out their fullest energies to reduce the high cost of labour as it existed to-day. A very large percentage of labour would be done away with by introducing the electric locomotive. With regard to shunting engines, Sir Philip Nash had given them some very interesting figures with regard to the trials which were made, but he believed if figures of the same kind had been got out with regard to goods and mineral working, they would show just as important results. Speaking from memory, he did not believe they got more than 8 m.p.h. or 9 m.p.h. out of their locomotives doing this class of work, and therefore it was perfectly obvious that a very large proportion of their time was occupied in standing.

He was asked the number of electric locomotives which were being used to replace the steam locomotives on the lines which they had been working. The facts were these. The work which was done on the Newport-Shildon line, which was entirely a mineral traffic, was worked previous to the war with 15 locomotives. To-day that same traffic was worked with nine locomotives. He had gone very carefully into the question of electrifying their main line, and he was convinced they would be able to dispense with about 30 per cent. of the engines if they were electric instead of steam.

He did not think they would find any difficulty in getting the necessary speed out of single-reduction gearing. Once they got a suitably-designed locomotive they would be able to run at a more uniform rate of speed over the line; they would not be crawling up some of the heavy gradients and rushing hurriedly down others in order to get the average. He did not believe in these very high speeds of 80 miles an hour to 85 miles an hour. He would like to see them done away with by getting a locomotive that would run more on an average speed of 60 miles an hour. With an electric locomotive one could take as much out of it as the machine would bear, and when one got to the top of a gradient the machine was just as good as when it started.

He was quite satisfied with the experience he had already had in electric locomotive design, that one could build a locomotive which would be very nearly 100 per cent. better than the heavy locomotives of to-day, and yet be able to get it within the present loading gauge. He had heard the point discussed about the symmetrical locomotive not being able to run at high speed, and could not agree with it because his and other railways to-day were building symmetrical steam locomotives which would run in either direction at very high speeds. He fully appreciated the point as to the manufacture of locomotives outside the railway companies' works, and he sympathised with the manufacturers in this country because many of the companies did this manufacturing themselves. He certainly thought, however, that with electric locomotives a great deal of work would have to be done by the contractors.

This concluded the proceedings of Sections III and VII of the Conference.

SECTION IV.—MINING AND METALLURGICAL PROCESSES.

THE EFFECT OF THE WAR ON MINERAL SUPPLIES.

At the meeting of this section, on Friday, of the 1st inst. Sir Richard Redmayne occupying the chair, the first paper taken was the one having the above title, by Mr. T. Crook. We reproduce it on page 165.

The Chairman drew attention to one important point in respect of fuel. The effect of the war had been, as Mr. Crook showed, to stop the advance in the production of coal during the war period, 1914 to 1919 inclusive; but it must be remembered in that connection, when comparing the production of coal fuel with oil fuel, that there had been drawn from the mines a great number of men of military age and fitness, not only in this country but in Germany and France and elsewhere, which of necessity had a very great effect towards lessening production. Then there were more persons employed now in getting coal, or were before the great strike, than ever before; but with a lessened production per man per head. This lessened production was due to a variety of reasons, amongst others war-weariness and ill-health; but he was not saying these were the only reasons by any means. But the reasons, such as they were, which had contributed to the decrease in the output of coal, would not obtain, he supposed, on the oilfield. The labour employed in getting oil was, of course, immeasurably less than was required for getting coal. Mr. Crook had referred to the progress in oil output taken in conjunction with the decline in the coal output. A point which made the comparison still more emphatic was the fact that whereas the thermal value of naval fuel oil might be taken as about 19,000 B.Th.U., the average thermal value of ordinary coal would be somewhere between 11,000 B.Th.U. and 12,000 B.Th.U.; so that you would have to multiply the oil output by a factor which would considerably increase the quantity when comparing it with the amount of head generated for the given output of coal. He took it that the proper means of comparison was the cost of thermal values. It became a question of cost entirely as to which you would use.

In respect of oil there was the added advantage that you had no ashes to deal with, and in the case of variable loads in power stations there was no doubt that oil presented certain advantages which coal did not. In the case of locomotives, especially on shunting, it was an advantage that you could turn the oil off or on as and when you liked. Probably one of the fuels of the future would be a combination of both—a mixture of oil and fine coal dust, commonly but wrongly known as colloidal fuel—whereby you obtained the same thermal value as from oil bulk for bulk, though, of course, not weight for weight. The resources available of oil in the world were an unknown factor, but we knew that an oilfield was very much more rapidly exhausted than a coalfield.

Mr. F. Merricks said the effect of the war on mineral supplies had been a disastrous one, and the present affairs being in a topsy-turvy condition, the future was difficult to foretell. During the war every effort had been made to produce the essential minerals to the utmost capacity, with the result that when the war ended it was found that there had been what was equivalent to overproduction. In other words, when the war ended a large surplus of every mineral and metal essential for each of the allied countries to continue the struggle had been found on hand. These stocks which had been accumulated as necessary war materials, at great cost, suddenly became a drug in the market under peace conditions; and their liquidation had not only been a source of great anxiety to the various Governments but it had been of serious import to business men. Until that liquidation had been completed, and the accumulated stocks absorbed by customers, normal conditions of trade and of values were impossible. The difficulty in this connection was that large sums of money had necessarily been locked up in holding these stocks, to which interest was now being added year by year. Before the war, the economic posi-

tion of the mineral supplies of the world had been more or less in a state of equilibrium; there had been a normal flow of the most economically produced minerals to meet the normal demand. But the war had upset this economic balance. The basis of values had been altered. Some materials of vital importance for war purposes being in short supply, advanced enormously in price, and consequently other materials of value under peace conditions became of little value. In this connection the rise in the cost of zinc to the Allied Powers might be instanced, while the Central Powers had been prepared to go to any length to secure comparatively small supplies of ferro-vanadium. With regard to Mr. Crook's remarks about the export of iron ore from China, it could be safely said that this went to Japan.

Mr. F. W. Harbord said the paper stated that the output from various countries had decreased so much per cent. If Mr. Crooks had given the actual figures of the principal countries of the world, these would have been more useful. Our production of hematite had been about 1,750,000 tons pre-war, and had only fallen 200,000 tons, notwithstanding all the troubles we had had with men being withdrawn to the front and the consequent shortage of labour. Our phosphoric ores had fallen during 1913–16 from 16,000,000 to 13,500,000, but between 1916–17 they had increased again by 1,500,000. So within a million we had got up to our best year's output pre-war, and had the war gone on we should probably have exceeded that.

Prior to the war we had probably produced a very large amount of ferro-manganese for export, and consequently imported far more of the ore than was required to produce ferro-manganese for home consumption. America was now getting a much more firmly-established ferro-manganese industry than she had had, and he was somewhat doubtful whether we should get Brazilian supplies over here to anything like the extent we had done before the war. During the war we had relied practically on Indian supplies.

From India also we had got a considerable amount of chromite. It was very good chromite, but our main supply was from Rhodesia; and this, of course, was still going on. Tungsten, of course, had been a special case. There had been a tremendous demand for wolfram. But at the end of the war, with the large accumulations referred to by Mr. Merricks, there had been a big slump, and the industry was now in a critical position. Vanadium was of great interest. During the war we had been obliged to rely on America, which had practically the only known deposits of any extent—in Colorado and Peru. America had also established a metallurgical industry which controlled this trade. There was the possibility of the development of vanadium in one of our Colonies, South Africa. We did not know the extent of the deposit, but it was quite considerable; and we hoped it might prove a source of sufficient vanadium, at all events to meet the requirements of the Empire. One point the author had not referred to in reference to magnesite, was that the magnesite deposits of India were very large and extremely pure. During the war we had got considerable quantities from India. Austrian magnesite was particularly adapted for refractory materials. The Indian magnesite being extraordinarily pure was particularly adapted for chemical purposes—for which large quantities were used—also for cement floors and so on. Since the war there had been considerable shipments. Graphite was a very curious case. During the war we had been very anxious to get our graphite from Ceylon; but the dressing of graphites depended very largely on their physical condition; and, so far as concerned graphites used for refractory purposes, we had found it extremely difficult, because the principal makers had altered their dressing plants to suit particularly Madagascar graphite. We had had to choose between dismantling the plants and putting up plants to treat the Ceylon graphite—which would have taken some months—or taking the graphite from Madagascar. Wisely or unwisely, we had arranged for supplies as far as possible from Madagascar.

The author had not touched on the zinc position, which had been very curious during the war. In Australia there were probably the largest zinc deposits in the world, at all events the most developed; and pre-war over 300,000 tons had been shipped to Europe every year. Not very much had come to this country. After the war had been in progress some time, we had begun to get very short, and then there had been a big strike in Australia which had held up the mines for over a year, with the result that we had had to rely on Mediterranean ores. The freight position had been extraordinarily difficult, and in the end we had been obliged to ration zinc users, so as to keep the works going with the least amount of disorganistion. That position had continued after the war, and, in fact, had not righted itself yet, although he believed the Broken Hill mines were beginning now to get to work again. It had been hoped that after the war we should be able to re-start our zinc industry in this country as we had the control now of all the zinc areas in Australia. The Australian Government had purchased these, and we should have been in a very strong position if it had not been for the coal; but in view of the fact that it took 5 tons of coal to make a ton of spelter, until we could get reasonably cheap coal, the economical production of spelter in this country was impossible.

Dr. F. H. Hatch said the United States production of iron ore before the war had been 62,000,000 tons per annum. This had fallen to 41,000,000 tons in 1914, but in 1917 and 1918 had risen to 75,000,000 tons. Since the United Kingdom had ceased to be a producer of copper ore, we had been dependent on the United States for our supplies, and production had been greatly stimulated in that country. Mr. Crook had referred to the largely increased production of nickel in Canada, but had not mentioned the similar large increase of tin production in the Malay States. With a return to normal labour conditions in this country, and the reduction of the cost of fundamental materials such as coal, we might hope that there would be a recovery, and that our tin, lead and zinc mines would once again be at work. The shortage of fertilisers had turned the attention of Germany to nitrogen fixation, and this would affect the Chilian nitrate market.

We had vast quantities of oil shale in this country, and if the experiments now being tried to get rid of the sulphur in these products were successful, a new and important industry would be opened up in this country.

In regard to the zinc position, the purchase by the British Government of the output for a considerable period of the Broken Hill mines was having a very deleterious effect on the home mine production; but of course the zinc smelting was vastly more important, so he was afraid the mining industry would have to suffer.

Colonel Carnegie said in Canada they had been faced during the war with the production of cartridge cases, among other things, and had no brass, but there had been a most enterprising backing from the Canadian Pacific Railway, associated with the Consolidated Mining and Smelting Company. This was only one of several large mining companies in the West which had undertaken to instal an electrolytic outfit—with some fear, for metallic zinc had never been produced in Canada. The result, however, was excellent. Zinc had been supplied from the States at prices ranging from 35 cents. to 40 cents. a pound. The company had no knowledge of the refining of zinc, but for some time it had been refining lead electrolytically, and on the strength of that knowledge it had gone ahead and undertaken to supply at 15 cents. a pound. It had undertaken to supply copper at the same time. All this had been the outcome of large supplies of electric power, produced from the Bonnington Falls. The magnesite produced in Canada was equal in quality to the Grecian and others, particularly for furnace linings. In regard to calcium carbide, the supply of which had been almost vital as a war necessity, Canada had done greatly in that respect also. In regard to ferro-silicon, Canada had done wonders at Welland where there were eight furnaces. Production had been increased fourfold during the war, supplying Canada, the States, France and England. Canada had been able to produce from shell steel turnings, which were becoming a drug on the market, pig-iron at a cost of 25 dols. a ton, in 1917. Asbestos had not been mentioned, and the increasing supply of asbestos from Canada had been of great value to our country. Speaking generally as to the effects of the stimulus during the war and the results now, it was difficult to say how far the increased capacity could be maintained. At the present time Canada was suffering, as the industrial world was suffering, from labour and other troubles; but it was a great country, and the hope was that it would not only be able to use its present capacity, but would go on increasing it.

Mr. H. Kilburn Scott said Mr. Crook had referred to the future of the Brazilian manganese industry being uncertain, and it might be of interest to state that the largest manganese deposit in the world—that in which the greatest quantity of ore had been definitely blocked out—had recently passed into the hands of the United States Steel Corporation. The difficulty with the manganese industry in Brazil now was that of transport. The uncertainty regarding the Brazilian manganese industry was due to the misuse of the carrying capacity of the Central Railway. It was true that with several of the deposits the cost of getting was becoming greater, and not very far in the future perhaps they might come upon poorer mineral in depth. With regard to the Gold Coast deposits, he could say that the quantity of mineral involved there ran into several million tons. The largely-increased cost of labour threw on mining engineers a very great responsibility in providing some means whereby labour waste might be reduced. Many of them, when visiting works and mineral properties, must have been very much distressed at the way labour was wasted throughout the world. There was a cry for more labour, but he did not think this was due so much to a labour shortage as to our inability to utilise it in a better manner.

Mr. A. G. Charlton said he would like to emphasise the importance of nickel steel as applied to various engineering purposes in peace time. Mr. Crook had not made any observations in regard to gold, and one point of considerable interest was that the fluctuating premium on gold must have considerably affected cost keeping with regard to the production of base metals.

Mr. Crook said that he had been told, as he was sure he would be told, that he had omitted many things from his paper. But he had been nearly distracted in his efforts to compress what he had to say on the effects of the war on mineral supplies into a paper of 1,000 words. He had drawn up the table that Mr. Harbord wanted, but found that this alone had taken up the 1,000 words, so had to start afresh. He had had to cut out wholesale things of interest that had been asked for in this discussion. He had realised that the function of his paper was rather to give a few facts to stimulate discussion, than to deal comprehensively with the subject as a whole. He believed he had succeeded in his object. One thing that had struck him particularly was the emphasis placed by Mr. Merricks on excessive production during the war—Mr. Harbord had touched on the same point—as indicating, or rather explaining the present slump. In this connection he would like to call attention to the point made by Mr. Kilburn Scott, about waste of labour and increasing costs connected with that. The two ideas were somewhat opposed to each other. Taking them together we saw that what we were faced with was not excessive production, for there was a famine in materials. People were requiring large supplies, but could not get them because there was too much to pay for them. As Mr. Scott had said, there was a great responsibility on the engineering profession, and, as he had also pointed out, in cheapening production by more economical methods of output, engineers would be stimulating consumption. The excess of materials was not over requirements but over demand, which was a different thing. Europe was starving for copper, and had been for some time; but could not afford to pay the price demanded by the United States for copper accumulated under expensive conditions of production. He had written on magnesite during the war, and had found that he required a hundred pages for that product alone.

THE UTILISATION OF EXHAUST STEAM IN TURBINES.

The second paper taken in Section IV on Friday, the 1st inst., was that bearing the above title, by Mr. M. Deacon. We reproduce it on page 165.

The Chairman said that some fourteen years ago, when managing director of the Stafford Coal and Iron Company, he had decided to utilise exhaust steam in the way Mr. Deacon had indicated, and the results had been most satisfactory. The very large amount of energy in low-pressure steam had not always, he thought, been fully realised. In many cases the policy represented by the plant which Mr. Deacon had described was sound economics. There could, of course, be no broad generalisation on the point. For instance, if the colliery load independent of the winding load was a heavy load, and not fully coincident with the winding load, it would often be found attractive to put down high pressure turbines and adopt electricity for all purposes at the colliery, including winding, as well as pumping, fans and so on. Mr. Deacon gave some very alluring figures of cost per unit from exhaust steam, namely, 0·2 of a penny. Unless the load factor was a very big one, it would be more profitable to draw electrical power from an electrical power station, where, of course, the small variations would be less marked. It was profitable to drive all continually moving machinery, such as fans, pumps, and so on, electrically; but such a very variable load as a winding engine was a different matter.

Mr. J. A. McLay said there was no plant of which the efficiency so much depended on the lay-out as an exhaust steam utilisation plant—particularly the lay-out dimensions of low-pressure steam piping. Obviously in a large output deep colliery, it was impracticable to impound all the steam exhausted from the winding engines; the blast of steam was so great, expecially during the acceleration period, that it was necessary, in estimating the output obtainable from the exhaust steam, to make considerable allowances for such steam blown to atmosphere, as well as to allow for the moisture in the exhaust steam. It followed from this, that in order to minimise the back pressure on the winding engines, the low-pressure steam pipes must be of more than ample area. In one installation he had investigated this point of ample area in the low-pressure steam pipes had been overlooked, with the result that the back pressure on the winding engines rose to 13 lb. per square inch above atmosphere. The boiler pressure was only 65 lb. per square inch gauge, so that the effect of this back pressure was to increase the steam consumption of the winding engines—certainly to double it. This in itself was serious enough, but the loss might have been minimised if the whole of the exhaust steam could have been used in the turbine. Unfortunately the load and accumulators were insufficient to take up the whole of this steam, and the surplus was blown to atmosphere. The result generally was that the colliery was worse off after the plant was installed than before. In dealing with exhaust steam utilisation at a colliery, another point that was often lost sight of was the problem of boiler feed water. Generally a colliery was badly off for this, despite which it was, if anything, the general practice at present to instal condensers of the jet type in conjunction with mixed pressure turbines. In his opinion, it was better practice from every point of view to instal surface condensers, and so to recover the distilled water made available by the condensation of the steam from the turbines. No doubt a surface condensing plant cost much more than one of the jet type, but it required less power to produce and maintain the same vacuum. There was also the risk of the impurities in the circulating water silting or sealing up the tubes of the surface condenser, but it was better to have that than scale in the boilers. Scale in the condenser tubes only meant a loss of efficiency, whereas scale in boilers not only meant reduced efficiency, but risk of an explosion.

Mr. Seymour Wood said he had for some considerable time past been connected with a colliery with about 4,000 tons a day—an output running back to the early days of 1834 or 1835. During the last three years it had become necessary to modernise this old colliery bit by bit, so as not to interfere with the output, and one of the modernisations carried out during the last fourteen years had been the scrapping of 24 boilers underground, and electrifying the whole system. The surface had been electrified at the same time, leaving practically only the winding engines consuming steam. There were two modern winding engines, running with high pressure steam at 60 lb. to the square inch, and there were two very old engines that had originally helped to sink the pit. The question of economy in working costs naturally came to the front. Power was purchased from the power company, and the colliery used the energy from the winding engines in the exhaust steam turbine—for the production of compressed air. Mr. Deacon used the exhaust from the winding engine for the production of electricity. The compressed air referred to by him (the speaker) was used for driving hauling engines underground, coal getters, &c. The experience gained had been practically on the same lines as that of Mr. Deacon: that at a colliery with an output of about 3,000 tons to 4,000 tons per day, you could get 2,000 h.p. economically for driving compressed air plant. If they had had a regenerative accumulator at the colliery in which he (the speaker) had been interested, they would have had even better results; but the results they had obtained had come out pretty well on the same lines as those of Mr. Deacon.

Mr. Deacon said that he had not made the calculation which Sir Richard Redmayne had evidently made with regard to two-thirds of the steam of non-condensing engines being wasted; but he should think this was probably accurate. Sir Richard had suggested that it might be economical to scrap existing plants, or, rather, to utilise existing plants—winding engines and so on—for electric power. In a great many cases this might prove economical; but his (Mr. Deacon's) general experience, and the result of many years of consideration on the question of the total electrification of a colliery, as against steam winding and electrification of the remainder, had convinced him that where the winding element was a very large one, it was more suitable and at the same time more economical to employ steam in the winding engines, and to utilise the exhaust steam for the electrification of the remainder of the plant. In the case of a rather deep bed the exhaust steam would be very nearly able to do this. It would provide pumping—unless this was abnormal and excessive—and the whole of the haulage. This, of course, was a point considered constantly by mining engineers when putting down new collieries. The only case in which he had come near to the point of electrifying the whole of a new colliery, had been on the basis of providing the power by gas producers—starting straight away from gas producers, generating electric power by gas from the producer, and doing without steam boilers at all. It would have been a great economy to have no steam boilers, but if a colliery were to be electrified by means of steam turbines, one still required the boiler plant, and it was not only an important item in outlay, but also a very important item in labour and repairs during the whole period of the life of the colliery.

He had never seen this idea of working the colliery straight away from gas producers in operation, but he thought it was the most economical method of carrying out such work. At any rate it would have been so some time ago; but it would be very difficult, with prices at three or four times as much as they used to be, to come to a definite conclusion as to whether it would pay now. Before the war, when prices for machinery were quite reasonable, he thought the method he had suggested would have been the most economical way of equipping and working a colliery. Mr. Wood's remarks with regard to the utilisation of exhaust steam for compressing air direct were interesting; he (Mr. Deacon) had not heard of exhaust steam being applied in that way before.

Sir Richard had suggested that he (Mr. Deacon) might be able to say what proportion of high pressure steam was used in the particular plants under his control. That would be a very difficult thing to say, because it depended almost entirely on the speed at which the engine was running. If the colliers were very industrious the engines would be kept winding all the day. On the other hand, one came to a slack day, when there would be some 20 per cent. to 25 per cent. of high-pressure steam to be used up. But the extent to which high-pressure steam was used was automatically arranged by a governor. It was only introduced to fill up a gap, slight or long as the case might be, when there was not sufficient exhaust steam in the accumulator to keep the generator running.

STEAM VERSUS ELECTRIC WINDING.

The third paper was the one having the above title, by Mr. W. C. Mountain. We reproduce it on page 166. In the absence of the author, it was read by the chairman.

Mr. Deacon, who opened the discussion, was of the opinion that to put down boilers at a new colliery for the purpose of generating electric current to perform the winding operations of the colliery, was not an economical project—partly because a modern winding engine of first rate design would perform its work on something between 30 lb. and 35 lb. of steam per indicated horse-power. If one put down an electric generating plant, the turbines would probably consume from 12 lb. to 14 lb. of steam, but there were losses, including friction losses in the generator right up to the winding engine; so that the amount of saving in steam could not be very great. Then one had to consider that the electrical plant would probably cost three times as much as the steam winding plant. Therefore, when calculating that, and reckoning the increased capital expenditure at a reasonable rate of interest, the cost of repairs practically counterbalanced the remaining steam which had not been accounted for between the consumption in the turbine and the consumption in the winding engine. So that unless power could be purchased from an electric system in the district, by which the expenditure upon a boiler plant might be avoided, he thought the question of totally electrifying a colliery was hardly on the most strictly economical lines. But here, again, other conditions might come in. There might be other collieries lying round about the main pit, to which to apply electric winding, and that might turn the balance in favour of putting down electrical winding at the main pit. That was undoubtedly a case where electric winding was applicable with advantage, in the same way as it was applicable in the case of underground shafts. It was sometimes found desirable, or even necessary, to sink a shaft from one seam to another underground. Steam down a pit was of course an old-fashioned and a condemned method. The winding in the case of a subsidiary pit underground must be done with electric power, compressed air or hydraulic power. Hydraulic power was not suitable for a winding engine because of the speed at which it had to run, and compressed air had its own disadvantages also. Electrical power was the best for underground winding.

If the colliery happened to be in a district where there were blast furnaces and coke ovens, very cheap power might be obtained, and electric winding might become very much more economical than steam winding. In that direction, very considerable strides had been made in this country on the lines of the proposal of the Government to divide the country into 16 electrical areas. If that was done judiciously the waste power in certain districts would be utilised, with very economical results. To a certain extent that had been done in the north of England. He hoped that as soon as the financial embarrassment of the country was modified, we should see some of the schemes for the utilisation of waste heat taking the place of the cumbersome and rather unbusinesslike proposal to divide the country up into 16 electrical areas, regardless of power required and cost of putting down large plants where condensing water might be obtained. The 16 large areas should be cut up into smaller sections, so that we should be able to utilise all our waste power; and then let the balance of the power be found by moderate plants placed in positions where they could get ample condensing water, and where the power would be required.

The handling of a steam winding engine was preferable to electric winding. Although electricity

was in many cases quite amenable, he thought it would be admitted that the steam winding engine was a more suitable machine for handling a load—not for straight winding, but for certain emergencies which might arise—than an electric engine. For instance, steam winding might be brought to a stand in case of necessity in much less time than an electric engine. He believed that a steam winding engine, winding at full speed, by reversing and putting on the brakes could be pulled up in about 10 ft.; but that in the case of an electrical driving drum nothing of that kind could be done. This was an important element, there being sometimes 30 or 40 men in the cage. For great rapidity of reversing, steam therefore was superior to electricity. He knew that Mr. Mountain had given a great many years' attention to the subject. It was a most difficult subject, and the paper was especially to be valued because Mr. Mountain was an electrical engineer; he was also such a thorough engineer that he drew a line in spite of his own pecuniary interests, and said there was a point beyond which electrical machinery was not economical.

Mr. Hugh Lupton asked Mr. Deacon whether he thought it possible for a colliery at times to draw upon a power supply company, and at other times to return power to that company. He (the speaker) thought it would mean putting the colliery generator into direct communication with other, very large generators; and it might be that the rush of current which would occur in the case of a short, rendered the system a dangerous one.

Mr. Deacon said he understood the question asked by Mr. Lupton was as to whether the surplus power generated during the process of working the colliery could be conserved for use at another time or passed into the public mains. There was no mechanical difficulty in the way. The only point was that in the active operations of a colliery, he should think that haulage was the principal active operation and that was going on at the same time as the winding. When the winding ceased, practically the haulage ceased, though it might go on for another half-hour or so. When the principal power had been generated, there was no further employment for that power until active winding operations began again, so that there was very little power generated that was not immediately used. It was found that the exhaust steam of a winding engine would be all taken up in a modern, well-equipped colliery in performing the hauling and pumping operations, and as soon as that steam was no longer available in consequence of the cessation of coal winding, there was practically no call for steam. It might be said that the power was consumed as soon as it was made. Otherwise there was no mechanical difficulty at all in returning power into the public main, or it might be the private main.

Mr. R. Nelson said Mr. Mountain had summed up the point most completely in the last paragraph of his paper. That conclusion was a perfectly sound one, and one not in dispute now. Of course, when a colliery was far away from a supply company's mains, as was often the case, it was not possible to carry out the policy. Such arrangements as Mr. Deacon had outlined were very economical. As he understood, Mr. Deacon used 33 lb. of steam to get 1 h.p. on a winding engine shaft, and with that same steam passed through a turbine and condensed he obtained a kilowatt; so that really he obtained more out of his exhaust steam than out of his live steam. That was an interesting reflection. Mr. Mountain gave very low costs indeed. He took 15 per cent. for interest and depreciation of capital, and reckoned this at 0·06*d.* per kilowatt, no matter whether it was exhaust steam, mixed-pressure steam or high-pressure steam. From this it appeared that he took the capital cost of turbine plant and condensers without making any correction for boiler plant—he must have boiler plant if he used high-pressure steam. That would alter the figures to some extent, but they were striking figures, and justified the policy of utilising exhaust steam in this way. He (the speaker) might answer Mr. Lupton by stating that there were several cases in the North of England where surplus coke-oven gases were used for the purpose of generating electricity, which was put into the public supply mains. From two of these waste heat stations in Durham, 40,000,000 units were generated. Only 10,000,000 were required for the colliery, the remaining 30,000,000 being sold to outside users. This was an economy of fuel amounting to several hundred thousand tons—a very substantial contribution.

Mr. M. Thompson said the same system was being adopted in Yorkshire.

The Relative Values of Protective Metallic Coatings for Iron and Steel.

The last paper taken at the meeting on the 1st inst. was the one by Mr. S. O. Cowper-Coles, having the above title. We reproduce it on page 167.

Mr. R. Nelson said it was new to him to learn that electro-positive metallic coatings differed from electro-negative ones in their action. This certainly was a very important distinction, and he recollected that Sir Robert Hadfield, in his address, had estimated that between 1 and 2 per cent. of all steel structures was lost every year due to corrosion. That percentage seemed very high.

Mr. M. Deacon said he would have thought the process ought to take the place of paint altogether. He had hoped that Mr. Cowper-Coles would tell them that his process was so vastly superior to galvanising that the coating never came off at all, and so the paint could be saved.

Mr. Cowper-Coles said, in reply, that unfortunately zinc was very soluble, especially in districts where sulphurous acid was formed; so that it was essential to any process employing zinc to give it a protective coating of paint. If the paint adhered and protected the zinc behind it the latter lasted indefinitely. Galvanising did not give a coating to which paint adhered, but electro-galvanising did.

SECTION V.—SHIPBUILDING.

Marine Turbine Reduction Gears.

At the meeting of Section V of the Engineering Conference of the Institution of Civil Engineers, on Friday, the 1st inst., with Engineer Vice-Admiral Sir Henry J. Oram, K.C.B., F.R.S., in the chair, the subject first taken was "Notes in Connection with Experience with Marine Turbine Reduction Gears," introduced by a note by Messrs. R. J. Walker, C.B.E., and S. S. Cook, B.A. This was read by Mr. Walker, and is given on page 167 of this issue. The discussion was opened by Mr. Summers Hunter, C.B.E., who remarked on the difficulty of measuring the actual reliability of any machine used for the propulsion of a ship, particularly when conditions varied to the extent represented by the high-speed liner or the warship on the one hand, and the ordinary tramp steamer on the other. Further experience must be obtained before the full degree of reliability would be achieved with gearing in full-lined cargo boats. Conditions varied so greatly, as, for instance, when fully laden and when running in ballast or light trim on a voyage across the Atlantic. When the ship was pitching, something was happening between the propeller and the turbine which had what might be regarded as a detrimental effect to the gearing. Eventually efforts now being made would overcome these difficulties. With the reciprocating engine, so with the turbine, the best conditions for reliability and efficiency were superheating, forced draught and oil-burning.

Another condition applying to merchant vessels generally was the necessity of maintaining as far as possible a continuity of the economical speed of the vessel. A question which was agitating the minds of enginebuilders, superintendents and shipowners was whether any information could be obtained as to the relative proportion of steam used or required by the auxiliary machinery as compared with the actual propelling of the ship by the turbine or reciprocating engine.

No development had ever taken place without a good deal of trouble. As a matter of interest, in looking up some data in connection with superheating the other day he was surprised to find that his firm's contract No. 1—which was built in 1865—provided for a boiler pressure of 20 lb. to the square inch, and included superheating. The main machinery used an ordinary condenser and the engine valve gear was of the Corliss type. The builder was John Frederick Spencer, a prominent member of the Institution, and a man who had the courage of his convictions. Comparing what was done in 1865 with what they were doing to-day, Mr. Summers Hunter said that there had been no very great advance, but they had obtained a degree of efficiency and reliability that was little expected then. At that time coal was probably 8*s.* or 10*s.* a ton, but even then the shipowner and engineer were striving towards the highest possible economy in fuel and steam consumption.

Mr. S. B. Freeman, whilst concurring generally in the optimism of the author's contentions, remarked that the double-reduction gearing had its drawbacks, which must be overcome. References to naval practice were not quite applicable since there are no double-reduction geared turbines in the Navy; they were confined at present to the mercantile marine, and were the cause of more or less acute trouble in certain steamers.

Whilst many factors were common to both single and double reduction gears there were, however, two major differences—the speed of rotation was very different, and there was the interposition of a secondary shaft between the first and last members of the gearing, and in those two differences the cause of the unduly large amount of trouble experienced with double-reduction gearing might be expected to lie. Inaccuracy in gear-cutting had been suggested as the principal cause of unreliability, and a diagram illustrating the condition of gearing after running 50,000 miles, although the ship had not been detained at all, showed that in one case every twelfth tooth in the first reduction wheel was somewhat thinner than its predecessor, which, when running at 500 revolutions a minute, caused very considerable vibration. Three small fractures had occurred in three sections of teeth in all those wheels and pinions. The high-speed pinions were of chrome steel of 50 tons tensile, and the low-speed of 3½ per cent. nickel steel. The broken off pieces were very minutely analysed, and the steel was found to be good. The extension of the fractures was due to fatigue. Many teeth made by different manufacturers had been examined, and in each case had revealed a bright crystalline face where the break was recent and a black polished appearance where the tooth had polished itself by the vibration. Inaccurate cutting was sometimes suggested as the only cause, but Mr. Freeman held the opinion that if this were so teeth-cutting was more inaccurate than generally admitted, and torsional vibration and consequent hammer blows was regarded as a more likely reason for a number of the unsatisfactory results.

Pitting or exfoliation, which had been experienced, might also be attributed to defective cutting or torsional oscillation, although it was difficult to explain the pitting action if the oil film was being maintained. Mr. Freeman believed that the consumption results with the turbine would prove in time satisfactory to the shipowner, and he hoped to realize the figures given in the paper.

Mr. J. Hamilton Gibson referred also to the slight pitting or flaking which occurred in many gears during the initial running and then ceased. The first gears of which he had experienced were accurate as regarded pitch, but the faces of the teeth were not absolutely smooth and had distinct protuberances about as thick as a piece of paper. After the first season in cross-Channel work a certain amount of doubt was raised since so-called pitting was very marked. It appeared that the slight protuberances were worn off by the rubbing together of the teeth, the material got rolled up, and was then pressed into the face of the teeth just at the pitch-line. The pits were usually concentrated along the pitch-line. A number of little pellets of steel were found afterwards in the sump of the gear-case, and on examination these pellets, it appeared, had been rolled up like little bits of cigarette paper, flattened, pressed in and then dropped out. The pits themselves were extremely shallow, and had a black appearance, making them appear deeper then they were.

If gears were not perfectly aligned there might be a certain amount of lateral movement between the spindles, the teeth might "dig in," and the load might be quite sufficient to break the teeth. It was

needless, however, to worry about the difference between a load of 500 lb. and 1,000 lb. per lateral inch. The trouble with merchant service gearing arose possibly from the fact that all the gears—the first and second gears—were incorporated together in the one casing, and it was probable that lateral movement of the spindles might account for a good deal, due, of course, to the attempt of the teeth to jamb into one another. With single gear it was evident that the pinion tended to separate from the main wheel. With double gears—that was, two sets of centres—if one pair of centres separated, the other one might close up, especially if they happened to be in line. He submitted that as the probable cause of some of the trouble.

It was important to try to maintain the centres of the spindles, if at all possible; not to allow the spindles to move laterally more than could be helped, and not any more than the teeth clearance would permit. Several sets of gears were in course of construction, in which the spindles would be more rigidly held than hitherto. In an ordinary bearing a certain amount of oil clearance had to be allowed; whereas, in the Michell journal bearing the clearance could be fixed within extremely fine limits. Information was required as to whether the economies which were usually obtained on trial trips were maintained on service, expecially when compared with sister vessels fitted with different types of machinery.

Mr. W. S. Sykes referred to his experience with gearing dating back to the Vespasian, and concluded that the hobbing process was not sufficiently accurate, and to inaccuracy of cutting he attributed all difficulties. A shaping process with specially-ground and hardened cutters was advocated. Whereas inaccuracies of $\frac{14}{1000}$ to $\frac{15}{1000}$ of an inch in tooth thickness were not uncommon, $\frac{5}{1000}$ of an inch excess thickness should be the maximum. In gears so accurately cut it was claimed that all difficulties such as wear and pitting were entirely overcome. An experimental single gear set giving 50 : 1 reduction was being tried out, and if successful, gave hope that the double-reduction gear would not be the only solution to the speed-reduction problem between the turbine and the propeller.

Mr. J. H. Narbeth, C.B.E., referred to the proportion of steam used by the main and the auxiliary engines as a most important factor, that ought to be more thoroughly investigated. This meeting, in welcoming the turbine, the reduction gear and the oil engine as means of ship propulsion, recalled to mind the trials of the Blenheim, which had the largest reciprocating engine of her day and developed 22,000 h.p. In the short time which had elapsed since then marvellous progress had been made. In connection with vibration he called attention to the desirability of reconsidering the propeller in relation to the light as well as to the deep condition of the ship. The time had come for tramp steamer owners to consider whether a smaller propeller with greater immersion, running at a higher speed, should not be adopted in conjunction with reduction gear. There was, of course, a very great prejudice against such a course, just as there had been against screw propellers when they were first introduced. He hoped that shipowners would combine in the carrying out of experiments on propeller and shaft efficiency at different immersions and speeds, and would suggest the placing of propellers a little further aft, making the ship a little longer and giving the propeller a little better chance.

Referring to American experiments, the necessity for the Melville-Macalpine gear was questioned. The development of the turbine had been a wonderful boon to the naval architect in removing shocks and stresses of all kinds, enabling very greatly increased power to be put into the engine room and at the same time saving space and weight.

Engineer-Admiral Anstey, R.N., detailed his experience with airship gearing, where inaccuracy of cutting caused pitting, subsequently overcome by rubbing the gears to remove the hard spots.

Mr. R. J. Walker, C.B.E., in replying, stated that with warships the proportion of steam taken by the auxiliaries and the turbines—a most important point—was easily obtained because very careful measurements were taken and very careful trials run, which was not the case with cargo vessels, and only when shipowners took a great interest in knowing exactly how the machinery performed, was it possible to arrive at an accurate estimate. The percentage of steam taken by the auxiliaries was as much as 30 per cent. in some ships. The importance of looking carefully into the quantity of steam going to the auxiliaries was not sufficiently emphasised. Where high-class auxiliaries had been fitted very satisfactory results were achieved, and it was pleasing to record that arrangements had been made with certain firms for measurements to be taken in some of their new boats to ascertain the percentage of steam going to the auxiliaries.

He saw no serious difficulty with gearing in the light condition of the ship. Many such experiments were made on the Vespasian, which ran for a long time to the Continent of Europe, coming back light for the sole purpose of seeing what would happen, but the gearing had shown no signs of undue wear; there was no racing, and the revolutions of the propeller were not accelerated more than about 10 per cent. or 15 per cent. When dealing with the question of the end movement of the secondary shaft in double-reduction gearing, Mr. Walker quoted from the author's paper before the Institution of Naval Architects' spring meetings (see ENGINEERING, vol. cxi, page 369), to which reference should be made. He did not wish to convey that the troubles arising from gearing were entirely due to inaccuracy in cutting and workmanship. There might have been defective material as in the case mentioned by Mr. Freeman.

He did not favour chrome nickel steel for pinions, especially when of the high tensile quality. Nickel steel of 45 tons tensile was more ductile; and a little ductility was essential. The 26 to 1 ratio of reduction had been adopted in the Cairnross, which, unfortunately, was at the bottom of the sea, though no trouble appeared to have arisen from that ratio. The limitation of ratio was due, of course, to the size of the pinion, which must not be too small nor the wheel too large.

The opinion of the authors of the paper was that the Macalpine gear was not considered necessary and was really an additional refinement.

Mr. Stanley Smith Cook, B.A., in further reply, said that in regard to the difficulties encountered by Mr. Freeman in a certain vessel and the apparent occurrence of fatigue fracture, he was of opinion that torsional oscillation troubles were entirely absent in that case. The only outside influences which were tending to produce any forced vibration of the propeller shaft were the varying impulses on the propeller. He thought that the case referred to would be that of a vessel with a long propeller shaft and the engines amidship, where the frequency of those impulses would be very fairly distributed over the critical period of torsional oscillation of the shaft. He was very strongly of opinion that that was a case of inaccuracy, and Mr. Freeman's diagram confirmed that view.

Mr. Narbeth had mentioned the Melville-Macalpine floating frame. Examination of gears after running had generally shown quite a good distribution of load along the teeth. Even where there had been excessive pitting or even undercutting of the teeth, the distribution of the load over the length of the teeth had been found to be satisfactory. The question of obtaining the necessary accuracy of alignment was one of careful workmanship and reasonable care. If good distribution could be obtained in that way there was obviously no necessity for the adoption of a floating frame. He was, however, in full agreement with Mr. Narbeth and Mr. Freeman that there was no palliative for inaccuracy to be found, in the floating frame or any other device. He did not include in those devices the creeping table, which was not a palliative for inaccuracy, but a means of obtaining greater accuracy, and experience seemed to show considerable advantages from its adoption, although if perfect accuracy could be obtained without it, there was nothing to be gained by adopting that method of cutting.

Referring to the question as to the largest ratio of reduction, with single-reduction gearing, he could see no limit theoretically to the figure, but practically trouble was experienced with a ratio of reduction in the neighbourhood of 30, owing to the enormous size of the gear wheel. In the other direction, the pinion became too small so that it was a purely practical question.

In conclusion, the chairman (Sir Henry Oram) referred to the cost of making accurate measurement of steam and fuel consumptions, which in Admiralty vessels amounted to 2,000*l.* per ship before the war.

DIESEL ENGINES IN THE MERCANTILE MARINE.

The second paper read at this meeting—"Recent Progress in Large Diesel Engines for the Mercantile Marine," by Mr. James Richardson, B.Sc., Assoc.M.Inst.C.E., is reproduced on page 168 of this issue.

Mr. Summers Hunter, C.B.E., in opening the discussion, referred to the fact that the changing over from the manufacture of steam to Diesel engines meant alterations in the machinery equipment of the shops, and also to the difficulties experienced in producing satisfactory Diesel cylinder castings from metals which experience had shown would give good results. When considering the large number of Diesel engines now being built, it was probable that certain types were more suited to certain qualities of fuel than others, although this was not considered to be an outstanding difficulty. Mention was made of the case of the marine steam engine in the early days when difficulties were encountered in burning low-grade qualities of coal.

Sir Archibald Denny, Bart., expressed a preference, as a naval architect, for the rotating steam turbine over the reciprocating oil engine, for reasons which made a strong appeal to naval architects. If, however, it was a fact that, by adopting oil engines, the same power could be got with a much smaller quantity of fuel, no sentimental or other objection would stand in the way of full development of this new prime mover. In the matter of foundry practice, he experienced precisely the same difficulties as the last speaker.

Mr. R. J. Walker, C.B.E., who next spoke, questioned the relative fuel economy of Diesel and other engines given in the paper, and gave the figure of 8 lb. of steam, or the equivalent of 0·6 lb. of fuel oil per shaft horse-power per hour, as the consumption of modern steam turbines and double-reduction gearing.

Mr. W. F. Rabbidge, referred to the motor-ship Narragansett, where 10 tons of fuel was found to be sufficient per day for all purposes, which showed in comparison with similar oil-fired steamers, that the ratio of one-third the oil required by Diesel engines as compared with oil-fired boilers, was borne out in practice under sea-going conditions. Reference was made to the present limitations of the oil engine, and whereas it was true that shore plants could burn almost any quality of oil fuel, he deprecated any attempt to go too far in this direction, and advocated for marine work a good quality of fuel oil.

Mr. S. B. Freeman, who followed, instanced the indebtedness of the shipowner to the internal-combustion engine, which gave him such a wide range from which to choose for his power plant. Progress now being made in this country showed that the Continental oil engine was not going to have it all its own way in the future. In regard to space occupied by machinery, Mr. Freeman instanced the case of a standard large cargo boat, where 4,800 s.h.p. of Diesel machinery on twin screws compared unfavourably with 6,500 s.h.p. turbines and double-reduction machinery, in respect of space and weight. The necessity of relying on the electrically-driven winch was also mentioned as a drawback to the adoption of Diesel machinery in its fullest sense. Attention was called to the paucity of information as to the power which various types of oil engines can consistently and continuously sustain at sea. The owner was now being offered large and small Diesel engines, and was promised the same power from each. If this problem was as simple as appeared superficially, everyone would demand the lighter engine. Perhaps the same analogy applied in the case of oil engines as with the steam engine where, with a vessel which had ample boiler capacity and a good reserve of power, the wear and tear of parts and the speed of the ship were

much more satisfactory to the shipowner than if he had paid less in the first instance and less had been received, although perhaps the test bed performances were substantially equal. In regard to fuel consumption the advantage of the oil engine over the steam engine was very great, but must be qualified by considerations regarding available sources of supply the world over of coal in relation to oil.

Mr. J. H. Narbeth, C.B.E., recalled to mind earlier optimism where the proposition of installing oil engines for driving battleships was fully explored, and referred to the ordering, by the Admiralty in 1910, of a number of Diesel vessels in order to gain most valuable experience, which no doubt had largely contributed to the development of this prime mover. Referring to the economy of the Diesel over the steam plant, Mr. Narbeth hoped that the Diesel engine makers were not yet satisfied because they had meantime beaten the steam engine and he called attention to the considerable amount of waste heat with the oil engine which might still be harnessed to do useful work. Progress with internal-combustion engines in general might continue to be slow until both craftsmanship and experience had developed considerably, and much thought must be given to reducing both size and weight, in which case double-acting engines ought to be considered. In regard to the possibility of internal-combustion turbines, it is sometimes forgotten that the medium escaping from internal-combustion engines was a very high-temperature gas in strong contrast to the steam engine where the power medium emerged at low temperatures and almost devoid of energy.

Mr. F. Leigh Martineau, in dealing with the question of maximum power to be obtained from a given cylinder, referred to the necessity of the low rating of internal-combustion engines, and to the table given in the paper where, if the highest figure was taken at 100, the lowest was 37, so pointing to some discrepancies since the rate of heat transfer would be approximately in this proportion of 100 to 37. With increasing size of cylinder this question achieves greater significance, and a size of cylinder will be reached where ordinary cast-iron will be unable to withstand the stresses imposed. In regard to waste heat, he stated that with normal engines the exhaust temperature might reach 1,200 deg. F., whereas with the Still system this was reduced to between 180 deg. to 250 deg. F., according to the load, so that the fuel consumption by the means of utilising exhaust heat had been brought down to 0·35 lb. of fuel per brake horse-power per hour with the low-compression Still engine.

Engineer-Commander H. C. Anstey referred to the advances which had been made with the oil engine, so that whereas previously principles had to be struggled with, to-day it was a question of types and the improvement of details. In regard to the maximum power to be achieved from a given cylinder, this speaker made reference to the ratio of mean to maximum pressure, which for practical economy should be as large as possible. Dealing with the heat transfer question, and the difficulty of cooling pistons, he thought the proper line of development was to abandon the idea of making larger cylinders and that high powers should be obtained by a multiplication of units, which did not necessarily mean complication since there were vastly more parts in the steam turbine than in the reciprocating oil engine.

Mr. James Richardson, in reply, referred first of all to the relative consumptions of steamers and Diesel-driven vessels, and urged that these comparisons should be limited to vessels of the same power, size, and speed, which ruled out at the present time comparisons between large turbine installations and Diesel engines. Figures given in the discussion had confirmed the ratio of 3 to 1, comparing an oil-driven steamer with a Diesel-driven vessel equipped with steam-driven auxiliaries. Had the latter been equipped with Diesel electric auxiliaries, the ratio would have been more nearly 4 to 1, and had the steamer been fired with coal then the ratio of fuel consumed would be increased to 5 to 1. The figures given by Mr. Walker for the consumption of steam with turbines and double reduction gearing only apply to vessels of very much higher power than was suitable for the Diesel engine at the present time. For the low-powered steam turbine and double-reduction installations with 200 deg. superheat, the consumption of fuel taken in his comparisons was from 1 lb. to 1·1 lb. of fuel per shaft horse-power per hour, which figures, he believed, were substantially correct at the present time for such vessels equipped with steam machinery of powers commensurate with those of Diesel engine vessels.

In connection with Mr. Freeman's comparison it had to be pointed out that 4,800 s.h.p. per ship with Diesel machinery was about the maximum obtainable to-day with the mercantile Diesel engine, and that some of the disabilities with these large Diesel engines in respect of weight and space occupied, mentioned by Mr. Freeman, would disappear in the natural course of progress.

In regard to the rating of internal-combustion engines, which point had been dealt with in some considerable detail by a number of the speakers, he stated that so long as the average grey cast-iron remained the basis material of marine Diesel engine construction, the power rating should be maintained at a moderate figure. Developments and improvements in the quality of the material available to Diesel engine manufacturers would, in due course, be taken full advantage of by the designer, such benefits would first operate in connection with land engines which were not called upon as was the case at times with marine plants to make replacements, refits and repairs at a distant port with the material that might be available there.

In connection with the subject of waste heat of internal-combustion machinery, there was no doubt that with increase in power per unit, this question became one of very considerable importance.

The proceedings in Section V were concluded by Sir Archibald Denny, on behalf of the members, thanking the chairman, Sir Henry Oram, and the secretaries for having so successfully discharged the work which had devolved upon them.

SECTION VI.—WATERWORKS, SEWERAGE AND GAS WORKS.

Compensation Water.

On Section VI reassembling on Friday, July 1, the first subject to be taken was "Compensation Water," introduced by a note contributed by Mr. Edward Sandeman; this is reproduced on page 169 of the present issue.

Colonel J. R. Davidson referred to his experience on the two Liverpool watersheds of Vyrnwy, with a total catchment area of 23,000 acres, and the Rivington area of approximately 10,000 acres on the Millston Ridge. He agreed that a large quantity of valuable water was being passed down the river practically to waste, and thought that some of the existing compensations should be revised; he knew of cases where most valuable water was not being used to the best advantage. In the case of Vyrnwy, Parliament decreed that, in addition to a uniform compensation of 10,000,000 gallons per day, in eight summer months for four consecutive days an additional quantity should be poured into the river; which raised the compensation water to an average of 13,500,000; but, as that had to be supplied in the summer months, it was more costly to Liverpool than if a uniform quantity of 13,500,000 gallons were passed every day of the year. It was said that the additional quantity was for the benefit of the fly fishers in the upper reaches of the Vyrnwy, but that was not so, because it absolutely ruined the fishing. The fisher people, in their anxiety to make sure that they got that water, insisted on it being brought from the very bottom of the reservoir, and the level of the bell-mouth pipe from which it was taken was fixed by Act of Parliament at a lower level than that from which the supply of the town was taken. The result was that what water they got was stagnant, and useless for the purpose for which it was intended. In the case of Rivington, they originally had had to pass something over 8,000,000 gallons a day down the streams; a portion of that had been bought up, but to-day a very large quantity was passed down for the benefit of certain fifth-rate bleaching and dye works, with the result that within a few hundred yards of the point where that beautiful water was poured into the stream, it became nothing but gross sewage; it was useless for anybody lower down, and was a most glaring case of waste of water. At Rivington the compensation as fixed by Act of Parliament was more than half the total available.

Mr. W. J. E. Binnie said it was most advisable to endeavour to get the provisions, which were now introduced into private Bills, altered. Could not some statutory arrangement be made whereby a penalty would be paid if one did not send the compensation water down? Such a provision was, in fact, contained in a good many Acts of recent years, but if it were generally introduced, one would know that during the severe droughts one could at all events stop the compensation water by paying a certain monetary penalty, which would really enable one to get the greatest possible use of the drainage area. The paper brought out clearly how many times, in some cases, the amount of the statutory compensation water exceeded what the river would yield.

Mr. F. W. Macaulay remarked that if there was any proper relationship between the amount of compensation water which had been fixed and the ultimate yield of the gathering ground for supply, then it appeared to him that the rivers naturally ought not to benefit unduly as long as the full quantity was not taken from the gathering ground for supply. If the compensation water were in the same proportion to the amount which was being taken for supply, instead of being a fixed ultimate quantity right the way through, there would be a surplus between that ration and the ultimate quantity which could be diverted to supply purposes, to the great benefit, of course, of the authority, because naturally, it would enable them to postpone the construction of further works on the gathering ground. In the case of the Elan supply, the compensation was 27,000,000 gallons a day, when the consumers were only capable of taking something like 25,000,000 gallons from the supply. The 27,000,000 gallons had been fixed in relation to an ultimate figure like 80,000,000 gallons. The river must have been benefiting by the difference between the 25,000,000 gallons and the 80,000,000 gallons. Supposing the compensation water figure could be reduced to 20,000,000 gallons, the 7,000,000 gallons per day saved would probably delay the construction of enormous reservoirs in the Elan Valley for many years.

Mr. K. P. Hawksley said the remedy for the anomalies referred to rested with the engineers themselves and not necessarily with Parliament. Referring to penalties, he strongly objected to its going forth from the Institution that penalties should be put in a Bill with the understanding that they could be evaded. In the old days they used to ask for clauses enabling them to purchase the compensation water from the mill owners; that was a proper and honest way, and was done in the Weardale case. In Sheffield it was arranged that when they were short of water, they could make terms with the mill-owners and purchase the water.

Mr. R. St. George Moore said it seemed to him the scientific basis upon which compensation water should be given was on the value of the stream during the minimum dry weather flow. They all knew that the great detriment to the use of water power in England was that for so many months in the year the machinery was of no value. He thought, if they could arrange compensation water on the basis that they were giving people something during the dry weather when their machinery was of no value, that ought to count for a good deal.

Mr. Percy Griffith said the cost of compensation was proportionately very much heavier in smaller towns than it was in the case of the bigger cities. From the point of view of the riparian owners, what was taken away? It was obvious that for the greater part of the year the abstraction of the water for supply did not interfere with the millowners and riparian owners. The prejudicial effect only applied to a very short period of the year. There was another side to the question; in many cases the excessive flow of the rivers in the wet season was a disadvantage to the riparian owners which was largely mitigated by the works con-

structed for water supply; and the mill owners were getting an advantage in that way, as well as having something which they did not have before, in regard to the minimum flow. It was, he thought, obvious that a water authority, in taking water from a certain source, should not be called upon to provide gratuitously a state of affairs which was better than that which was pre-existing. To give more water to the stream than the previous minimum flow was certainly not, in his view, properly called compensation; it was a free gift.

Mr. S. C. Lewis said that for many years past it had been the fact that, to go to a Parliamentary Committee and propose to give less than a third of the rainfall as compensation, was simply drawing a hornet's nest about one. If a community started a new scheme of water supply on an undeveloped gathering ground, it was first of all faced with enormous expenditure in constructing a reservoir far beyond its immediate needs, in order to store the compensation water. The expense to the community might be mitigated if the compensation water went on an increasing scale according as the gathering ground was reservoired. Referring to the Birmingham supply the Elan Valley was fully reservoired, but the reservoirs on the Vyrnwy were yet to be constructed; yet the compensation water was being paid to the river in respect of the two sheds; it would have been fairer if the compensation water were paid in full in respect of the Elan, and only a small quantity in respect of the Vyrnwy.

Mr. C. G. Henzell said in many cases they would find long stretches of river where there were mills at far distant intervals, where, if one had to send down water continually during the whole year, it seemed to be a great waste at times when water could be better used for domestic consumption or for the consumption for which the reservoirs were particularly made. In his undertaking, the compensation clause required a continuous stream to be sent down. So great was this expenditure that, some fifteen or so years before, his corporation bought up all the mills as far down the stream as nearly 20 miles below the reservoir, and they found it was a very great benefit in enabling them to conserve water. Whether compensation water should always be contained in a separate reservoir over which the mill owners had entire control, or whether they should make the storage reservoir and the compensation reservoir in one had to be considered, but it seemed to him the great point with regard to compensation water would be to make a reservoir for compensation, and let the mill owners and those interested in the streams have full control of it.

Mr. F. J. Dixon said there was a very good compensation clause in the Stockport Waterworks Act, which he believed dealt with the available yield; it specified a ratio of the available yield. Referring to the Pennine district, when he had control there, compensation water was discharged into the river on five working days for 12 hours, for 6 hours on Saturday and none on Sunday, for the express purpose of supplying the various mills. They were not called upon to give full compensation until the works were completed.

Mr. C. H. Priestley stated that at Cardiff they did not give compensation in respect of the whole drainage area. Under their Act of 1884, the drainage area itself being 10,000 acres, compensation was to be given in respect of 4,000 acres of the area which was first utilised, at a certain rate, roughly 3,000,000 gallons a day; and when the whole area of 10,000 acres was utilised, as it would be shortly, the compensation would then be on the full area and equal to 7,750,000 gallons a day.

Mr. Binnie referred to the principle of fixing compensation water on the basis of the average rainfall, and took, as an illustration, the River Alwen and the River Thame, which supplies Birmingham. In the one case compensation water would be fixed on the high rainfall over the Alwen shed, which was nine or ten times the actual flow of the river in dry weather, while in the case of the Thame the quantity of compensation water would be less than the minimum flow of the Thame; one had only to take that four-fifths rule down to a very low rainfall, and one got no compensation water at all.

Pipes for Pressure Conduits.

The next subject taken in Section VI was that of "Pipes for Pressure Conduits," introduced by Mr. F. W. Macaulay, whose note will be found reproduced in full on page 168 of this issue.

Mr. H. F. Rutter said the influence of London water on cast-iron pipes was negligible. He had a fortnight before taken out, owing to a small defect, a 30-in. pipe which had been in use for the last 110 years, and had found the surface of the interior in every respect as good as on the day it was laid. No doubt pipes of cold-blast iron made in the early days of pipe founding were far superior, not only from the point of view of the material, but from the point of view of the operation of water upon that material than those of hot-blast iron of the present time. With reinforced concrete pipes the low initial co-efficient of friction and its maintenance were very important considerations. In regard to reinforcement of the concrete pipe it was a simple problem: the difficulty arose when they had to consider the best form of joint. Looking after work which has been put in during the last 100 years or more showed that, had that work been originally constructed as it should have been, without any additional expense, the expense for maintenance would be far lower; 50 per cent of that expense was unnecessary. On one portion of his system there was a 30-in. main turned at right angles by means of cast-iron socket bends of 40-ft. radius. From the time the main was laid, that particular curve involved all sorts of repairs; they were always opening it out and caulking joints. When he took control he took out the joints, and relaid them. It had been an awkward job; at pre-war prices, the cost of relaying was a little over £300. The previous repairs must have cost another £300. Had the bend been laid properly in the first place the additional cost might have been 25*l.*; so that they had a clear loss of 575*l.*

Sufficient attention had not been paid to the supporting of the bends. The unbalanced pressure might amount to something like 20 to 30 tons, and the stuff taken out of the trench could not be replaced so as to afford adequate support. In such a case the only thing to do was to interpose some rigid material between the casting and the virgin ground at the side. In treatises on water supply reference to pipe-laying was relegated to a wholly inadequate chapter at the end of the book.

Some years ago a trench of an important main was blasted through rock to a depth of from 12 ft. to 20 ft., and the main was laid on the rough bottom on the trench so that in some cases the 12 ft. length of pipe was only supported on three or four knobs of rock. The trench was filled in with shattered rock. On the main being charged it burst and many thousands of pounds were involved in putting the matter right. The mains should have been laid on packings a few inches above the trench, and concrete filled in under so as to give the main continuous support. If the vertical weight was serious, they ought to fill in concrete at least up to the horizontal line.

Mr. A. Pearce said he had laid about three-quarters of a mile of 24-in. Bonner reinforced concrete pipe, and about 300 yards or 400 yards of 36-in. pipes of that type. He was proposing to use the same kind of piping for a second pipe-line of about 30 miles in length, but that was not yet definitely decided upon. They had used the bituminous joint for low pressure, but the hot lead joint, not of the socket and spigot kind, was one which he would certainly use for anything over a pressure of 50 lbs. per square inch.

Mr. W. J. E. Binnie said he had got the Stanton Iron Company to make some experiments on collar joints, using an ordinary collar on the outside of the pipe, the water pressure being 175 ft. head. They had first of all tried running the lead, but that was found to be impracticable. Caulking with lead-wool seemed to be successful. It was used in India, where it was anticipated that after the pipe was laid there would be a very considerable contraction in the pipe-line as a whole when the water entered.

Mr. C. G. Henzell said that in Leeds, in their Weardale pipe, for something like a length of 13 miles, they had four 30-in. pipes which, when laid, were capable of running 10,000,000 gallons a day. Within 15 years the capacity had fallen to a little over 6,000,000 gallons or something like 40 per cent. reduction in capacity. His only trouble with regard to the Bonner pipe was in the joints. This type of pipe would eliminate to a very great extent incrustation; and if they could get a joint that would be absolutely as sound as that of a cast-iron pipe, there was no doubt that they would, wherever possible, use the concrete pipe. The incrustation in concrete pipes with Leeds water was less than in iron pipes. In Leeds in a year they spent 2,500*l.* in cleaning out and renewing small cast-iron service mains. In regard to the Une pipe, some months before, he had asked the Stanton Iron Company if they were prepared to lay down about a mile and a quarter of 12-in. pumping main, which he was quite prepared to put in if they would guarantee the joint. As members were aware, the Une pipe had been only made in 6-ft. lengths, but he understood they were being made longer now; but a waterworks engineer was not prepared to take a new pipe unless the makers of the pipe were prepared to guarantee the joint.

Mr. R. St. George Moore said that in 1913 he went to Paris especially to see a Bonner pipe that had been successfully working there for about 20 years, so that that type of pipe was not new. It was not laid in the ground or supported by the ground round it, but was laid in a tunnel. When one listened carefully, one could hear every stroke of the pumps driving the water through it, so that there was clearly a certain amount of vibration in the pipe. A steel pipe in the same tunnel doing the same work had given constant trouble. M. Bonner had given the joint question much consideration, and had realised its difficulties perhaps more than any other maker of ferro-concrete pipes. The only objection to the Bonner pipe was its cost. It was caulked with lead tubing filled with hemp and then cemented over.

Mr. Percy Griffith asked what was the minimum size of pipe to which reinforced concrete could be advantageously applied, and was there any very serious difficulty in regard to distribution and service mains in adding connections and making the alterations, particularly tapping services, which, of course, was a question which arose in every case of distribution mains?

Mr. Macaulay, replying, said he was not specially an advocate of the Bonner pipe. It had been the first pipe he had come across which seemed to meet his requirements. The pipe referred to in his note was of 60 inches diameter, and they had just finished laying and had tested it. It stood a test pressure of 135 lbs. to the square inch at the lowest point. It was perfectly satisfactory as far as the pipe itself was concerned, and on the whole as far as the joints were concerned. The contractors were a very long time in getting the pipe in, and it was subject to the difference of temperature between summer and winter, while not filled with water. The only place at which there had been any leakage was at the joints, 20 in number, which he had very little doubt was due to the contraction. What he had observed led him to approach M. Bonner with regard to the form of his joint. In the construction of the Bonner pipe there was a steel cylinder which was supported internally and externally with reinforced concrete. The external concrete was naturally the heavier, and was the real strength of the pipe; but for jointing purposes, the exterior concrete was stopped a few inches short of the spigot end of his pipe; and therefore there were some 9 in. on each pipe, consisting merely of inside protection reinforced concrete and the steel tube. On that he made his joint: the tube was not more than 2½ mm. in thickness, and probably at the outside 5 or 6 mm. The joint consisted of an equally light steel piece caulked with lead piping filled with yarn. The first difficulty was the tendency of the spigot to deform. In order to give that joint-section strength, a heavy reinforced concrete collar covered up the whole. The joint was very heavy, but the result was that the pipe became exceedingly rigid. If anything went wrong with the caulking, however, it was exceedingly difficult to get at it to repair. M. Bonner had consented to alter the design of his joint to make the length which projected beyond the concrete strong enough to form

an ordinary caulked joint. With regard to the Une pipe, he was not surprised to hear a run joint was not successful: the temperature of melted lead was far too high to subject concrete pipes to, but he did not see why an ordinary joint should not be made with lead-wool. Whether the pipe was laid at a great depth or in shallow ground, it should be unquestionably supported up to the haunches: the strength of a pipe supported in that way was increased 100 per cent. against outside pressures. He was hoping to revert to steel tubes lined with concrete and laid in that way, supported to the horizontal axis with concrete, and free to expand and contract longitudinally.

The Relation of Run-off to Rainfall.

Mr. Herbert Lapworth, D.Sc., was next called upon to read a note introducing the subject of "The Relation of Run-off to Rainfall." This is reprinted on page 169 of this issue.

Colonel J. R. Davidson said that in regard to this subject the law was laid down with elaborate formulæ based on what, he considered, were entirely inadequate observations. In connection with the Vyrnwy watershed they had records of the yield of that watershed for 30 years. Although it was true that, owing to the underground water storage, it was quite impracticable to arrive at a relationship between the monthly rainfall and the monthly run-off, yet he claimed that at Vyrnwy they had, within very reasonable limits, been able to say there had been a direct and simple connection between rainfall and run-off; and he had been so encouraged by this that he had tried to work back on the Rivington shed. Their gauges had been greatly improved recently, and he now found that the records of the last few years were beginning to agree, and it looked as though they would get a similar relationship to that of the Vyrnwy. Evaporation was greatest, as a rule, in a year of greater rainfall. That fact was well borne out in the case of the Vyrnwy watershed where he found from the standard gauges giving 80 in. that they got evaporation or total losses of 11·8; while if they took a year with 40 in., they got a corresponding figure of 3·7 in. of loss. The curious thing was that Rivington was the reverse, the evaporation being greatest in years of low rainfall. There when standard gauges gave 50 in. of rainfall, the loss was 7·6 in., while in a year of 30 in. the loss was 10·75 in. This could be accounted for by the fact that the Vyrnwy shed was all more or less impervious whereas the Rivington shed on the Millston Ridge was a formation in which the water did make its way down into the rock and was given out in the form of springs in dry seasons.

Mr. St. George Moore said that Dr. Lapworth asked for some statistics about an average rainfall of 100 in.: he (Mr. St. George Moore) had got some about one of 94 in. at Bombay. The previous year he had had occasion to be in Bombay, in connection with the water-works, and had been asked whether the present watershed of the Tansar district would yield 90 million gallons a day for the supply of the town. He found, fortunately, in Bombay records which made the problem quite simple. For the purpose of comparison, the practical observations taken in the year 1915 were those selected as the year which had a run-off, near the average of 94·34 in., taken over about 34 years. The quantity of water delivered into the aqueduct was 10,719 million gallons; the amount of water which flowed over the weir during the monsoon from the 6th August, was 23,013 million gallons. In March, 1915, there were about 13,000 million gallons in the reservoir, and in March, 1916, 21,000 million gallons. Therefore, the amount which was taken in the lake in March, 1916, more than there was in the lake in 1915 must be added to the amount drawn, and the amount which flowed over the weir, to give the amount of water available during the year, namely, 8,000 million gallons, giving a total of 41,732 million gallons. From that figure must be deducted the evaporation. That was worked out on the average for that of about 206 days a year, because during the monsoon it was no use gauging. Deducting this left 37,932 million gallons in the reservoir. On the basis of that one was able to say that the reservoir, if raised a specific number of feet, would supply the town with 90 million gallons per day, with the exception of two years, in the last 20 years, when the monsoon failed, and the rainfall was less than the required amount.

Mr. W. J. E. Binnie said that simultaneously with the gaugings which they had taken at Vyrnwy, referred to by Colonel Davidson, gaugings had been taken of the Severn at Worcester, which had a very much larger drainage area, namely, one of 1,860 sq. miles. They were not taken over an actual weir, but by ordinary velocity meters. The Severn had a rainfall of 35 in., for which Deacon's diagram would have given 198 days as being necessary to equalise the flow, while Hawksley's diagram would have given 189, so that they practically agreed at that rainfall. The actual amount of storage required from the gaugings of 1886, 1887 and 1888, in order to equalise the flow of those three dryest consecutive years, worked out at 161 days. Then they turned to a small drainage area, Trenchfort, that was also carefully gauged through that same dry period, 1886 to 1888. That only had a drainage area of 961 acres, The average rainfall there was 41·5 in. The storage required, according to Deacon's diagram, would be 179 days, while by Hawksley's diagram it would be 174 days; so that there was not much difference.

Mr. Thompson thought all of them had probably been disappointed when they plotted rainfall against run-off to find to what an extraordinary degree their plotted points varied over the diagram. Dr. Lapworth was quite right when he pointed out that one of the primary missing factors was ground water storage. The more permeable the drainage area was, the more important became the question of ground-water storage. One of the most porous, permeable areas in this country, if not the most permeable, was that of the chalk, especially the upper chalk. All the rainfall went into the ground, and for that reason on chalk it was necessary to rely upon percolation gauges. They had learned quite a lot from such gauges which, however, suffered from certain disadvantages. In very dry periods the gauges were probably dried right out, whereas in the actual soil a certain amount of water was drawn up from below, so that evaporation loss still went on in nature. The gauge, moreover, took no account of the enormous ground-water storage in the chalk. Another way of approaching the problem was to use the fluctuations of well levels. By taking a number of periods during the winter when the percolation was at its maximum, and comparing it with the rainfall over the same period, it was possible to get a relation between the rainfall and the fluctuations. And it was possible to measure the depletion by the underflow; in other words, the amount given out by the springs further down the valley. It was possible also to measure the amount of percolation at the saturation level, and to calculate the amount of evaporation at the surface.

Mr. Gerald Lacey said a recent formula was given at the end of Dr. Lapworth's note of the maximum flood discharge for British upland impervious gathering grounds. They would notice that formula was Q 500 M. In India they had had a formula of that type for the last 40 years. It was General Dickens' formula; and that formula was used in their works. It was

$$Q = K M^{\frac{3}{4}}$$

K = 1400 for the Central Provinces, and 1200 for the United Provinces.

There was another formula of the same type, Ryves' formula. It was $Q = K M^{\frac{3}{4}}$ Strange, who was an authority for run-off in Bombay, in his work on "Indian Storage Reservoirs," gave a table which could be plotted, and worked out as $Q = 1940 M^{\frac{3}{4}}$. Then there was Mr. Morley Parker's formula for England: $Q = 500 M^{\frac{3}{4}}$. In the Central Provinces in India, Major Garrett, produced a formula for a prolonged flood. It was $Q = 37 \times m \times p \times M^{\frac{3}{4}}$ where m is the greatest recorded rainfall in two successive days, p is a factor depending on the condition of the soil. Those formulæ were used in India with success, within certain limits. In Burmah the Ryves' formula and Dickens' formula were both used, by putting in a different constant.

In India they had a regular rainfall cycle, and in the United Provinces they had the monsoon from the middle of June till the middle of October. It varied in its duration and in its intensity and regularly, when it came on the ground, the ground was dry. If they could select years in which the duration of the monsoon was the same, then the only variation would be in the inches of rainfall for that year, and he thought it was fairly evident that if one were to plot such results, one would find the percentage run-off would increase with the total rainfall or monsoon of equal duration. The monsoon came in showers with intervals between them, during which the ground dried to a certain extent, and with two or three breaks in which the ground got remarkably dry, though not perhaps so dry as at the beginning of the season. One would expect that a monsoon of half the rainfall and half the duration would give one very much the same run-off, and it did in fact.

Dr. Salter said knowledge of the product of any watershed was very essential if we were to study our resources in a general way and not piecemeal, as we had done hitherto. In the case of the actual flow of streams, the data had not been co-ordinated with the same care as had been done in the case of rainfall. Observations of percolation and of evaporation were probably difficult of interpretation, especially the last. Engineers were rather prone to accept one or more records of rainfall taken more or less haphazard in convenient places on their sheds as representing what was actually occurring over the shed in general. The geographical variations of rainfalls over such an area as constituted an ordinary watershed were very great indeed. The rainfall observations taken down by the reservoir did not necessarily by any means represent what was taking place on the mountain from which a very large part of the water was flowing. It was rare indeed for a rain gauge stuck on a mountain to record what actually fell. There were all sorts of wind eddies blowing round it, and especially when snow fell, any average rain gauge, unless it was placed with great care indeed, would not give an accurate record of what was happening.

Until they had full confidence in the accuracy of their rainfall records, they could not expect to get any relation between them and the run-off. The errors of which he was speaking amounted to 20 per cent. or 30 per cent. They had tried to carry out a pooling scheme with regard to information on rainfall. It was very imperfect in some respects, but he hoped that it might be improved; but he felt it would never be of its full value unless other information was collated as well in a more general way. He believed that the evaporation was more or less a constant, but that when the shed was dry, evaporation could not take place, and therefore some deduction had to be made in dry years; but that the evaporation would never exceed a certain limit. When one made a deduction for the period when the ground was dry, one got a difference which appeared to suggest that the evaporation varied with the rainfall. He thought Colonel Davidson would find in general it was not a function of the rainfall.

Mr. F. W. Hodgson said that in England they were troubled by the fact that they took rainfalls for a year ending in December; they measured run-off in the months and plotted the run-off in a month against the rainfall in a month and then tried it for the whole year. There could not be a worse time in which to cut the rainfall year into two than the 31st December. Our effective rainfall was very much like the monsoon rainfall. By "effective rainfall" he meant that portion of it which we could get for use, and it was that portion which came in the six winter months of the year. They had a useful period of rainfall and a period where the rainfall was only sufficient to meet the evaporation. Almost every watershed varied, from the chalk to the rocky type. But even in the rocky type there was a considerable holding up of the water; and where the watershed did contain a large and porous mass, the rainfall of the winter was piling up in October, November and December, January, getting higher and higher in the rock, and running in some form of a square root curve right through to the next

September. That was the basis curve of the problem. On to that they had, both in the winter and in the summer, excess rains which ran off very quickly indeed. He would also like to point out that rainfall and flow-off was a continuous problem. All the year through the one plotted against the other, and the effect of heavy rainfall in a wet winter would be shown in almost all the average watersheds of England, at all events right up to the following September.

Mr. F. S. Robins said as the engineer to a large trading area in Lincolnshire he had terminated his year at the end of September. For that there were two reasons: (1) No floods had occurred in September since the new outfall had been made in the River Witham in the year 1884; (2) September was a good end to the calendar. They got the flood months starting in October with a number of 8 floods in 47 years, in November 15 floods, in December 23 floods, in January 26 floods, February 26, March 14, April 5, May 11, June 2, July 3, August 4. September had had four floods before the New Cut was made; since then it had had none. One noticed a gradual rise from October to December, and the maximum floods in December, January and February, with the falling-off again right away down to September, with the exception of May, which was also a flood month. He quite understood that the waterworks engineer was only concerned with a few dry months, *i.e.*, the minimum and the average. Upon the records of those the waterworks engineer could get his gathering ground sufficiently large, but he (the speaker) wanted to know the maximum flow-off in 24 hours. In the fen lands most of the water was pumped, and one had to deal with the water which came down very suddenly. For instance, they had had to deal with a flow-off of 11 in. in 13 days, which gave an average of 0·872; 4·24 in. in 4 days, an average of 1·06. In two cases of very carefully gauged rivers in which the conditions were much the same, rain, snow and then frost, a quick thaw and a heavy fall of 1¾ ins. of rain produced a very bad flood. The run-off from 70,000 acres of steeply inclined various kinds of land, meadow land, pasture land, and wood, was at the rate of ¾ in. of rainfall per 24 hours. That in cubic feet was about 2 cub. ft. per acre per minute. The run-off of an adjoining upland area of 29,000 acres into another river, the dividing watershed being between the two rivers, was at a rate of half an inch over the area, or at the rate of 1½ cub. ft. per acre per minute. The second river was through very much flatter land than the former, and the land was also less in area. The sub-soil was the same in each case.

Dr. Lapworth, in reply, referring to the questions as to formulæ, said a good deal had been said for and against formulæ; but after all, one had to get on. He quite agreed as to the periods at which the loss should be taken. September seemed to be more usual to end with, both in America and in this country. What was really required, it seemed to him, was for somebody to tackle the problem of rainfall who was a good mathematician with a certain amount of common sense, and who would work out some practical method: it did not matter whether it was really accurate or not—but to give them some method of anticipating, given certain conditions, what the rainfall would be. At the present it was absolute guesswork. He quite agreed with Dr. Salter that error was probable in gaugings, and the errors in river records were due more to rainfall than the actual methods of measuring the flow. He quite agreed also that the evaporation losses were probably a constant, and what he thought probably happened was that in each month up to a certain rainfall there was a gradual increasing evaporation, but when one got beyond a certain rainfall that loss remained constant and was not exceeded.

The proceedings of Section VI terminated on Friday, the 1st inst., with a vote of thanks to the chairman and the honorary secretaries.

SECTION VII.—ELECTRICITY WORKS AND POWER TRANSMISSION.

Battery Locomotives.

At the meeting of this section, at 10 a.m. on Friday, the 1st inst., Mr. C. P. Sparks was in the chair. The first paper down for discussion was one entitled "Battery Locomotives," by Mr. J. Dalziel. It was read by the author. As we reprint the paper on page 170 of this issue we may at once proceed to the discussion.

Sir Henry Fowler was the first speaker. He said there were about the country a very large number of branches, 3 miles or 4 miles long, on which trains ran two or three times a day, which had sidings with, perhaps, two points on their way up. It would be inadvisable from the financial standpoint to equip these branches either with overhead wires or the third rail, and in such cases the battery locomotive should prove extremely useful. On the Continent such locomotives were commonly incorporated with the passenger vehicle, but a steam locomotive which went up a small branch not only handled passenger traffic, but also did some shunting at the terminal and intermediate stations. When dealing with these small country branches it was necessary, therefore, to have a locomotive separate from the passenger vehicle.

Mr. C. H. Merz said battery electrification had the great advantage, compared with most electrification schemes, that a great deal could be done at a very small expenditure, and more trials of the kind mentioned in the paper might be made with great advantage. There was a good deal of experience to be got, which might result in proving that the battery locomotive would be extremely useful for shunting and handling small lines generally.

Mr. Roger T. Smith said the author had claimed that the battery locomotive could often usefully replace the horse or the capstan for shunting, and he would like to say a few words with regard to the use of capstans as compared with a battery locomotive. In a particular yard, where minerals were loaded into ships, all the shunting and turntable work was carried out a good many years ago by horses, and the annual cost was approximately 3,000*l*. The horses were replaced by 14 Clyde capstans. The 3,000*l*. which the horses previously cost was reduced by a half with the capstans, but the advantage was much greater, because the horses could only pull one loaded wagon at a time, whereas a capstan of this type could pull a train of at least 200 tons, and when the yard was worked by horses a steam shunting locomotive had to come in, certainly in the morning, and from time to time during the day, in order to push the trains into position so that the horses could deal with the individual wagons.

To-day a Clyde capstan, according to the work it did, cost, for electricity and maintenance, from 20*l*. to 40*l*. per annum, and the point was that the capstan was worked by the ordinary yard staff. Whenever a battery locomotive could be worked by the yard staff, of course, the cost of working was very appreciably reduced. On the basis he had mentioned, however, 8 to 10 Clyde capstans could be used for the cost of a battery locomotive, but if a qualified driver had to be used for the battery locomotive that would add about 200*l*. a year. It seemed to him that the comparative advantage of the battery locomotive and electric capstans depended almost entirely on whether the locomotive could or could not be worked by the ordinary yard staff, and he would like Mr. Dalziel's view on this point under present labour conditions.

Mr. F. Lydall said that looking at the particulars given in the paper of the performance of the Midland Railway battery locomotive, it was seen that it did 180 shunts per day for 300 days in the year, this figure being worked out from the ton-miles. That seemed to be a good performance, and he doubted whether any kind of shunting locomotive would do much better. The locomotive was a small one, and would not be of very much use for shunting in main line goods yards, but perhaps a few figures with regard to shunting in such yards in the States might be of interest. The results were taken from the average of 103 tests in 66 yards. The average length of run was 628 ft.; the average time of the run 79½ seconds; the average time of stop 53 seconds; the average speed in motion 5·4 miles an hour; average speed, including stops, which he took as meaning the whole period the locomotive was in service, 3·24 miles an hour, and the average load 306 short tons. If shunting was to be done by battery locomotives in goods yards in this country he thought we should have to consider a very considerable-sized battery, if the locomotives were to handle full-size trains, unless one was going to re-charge at very short intervals.

If it were possible to charge the batteries from an electrically-equipped section, then a very much smaller battery could be used. He would like to know whether it would be practicable to charge the battery intermittently from an overhead line or third rail, or would it be necessary to instal a motor generator on the locomotive and transform down to the pressure of the battery from the line pressure. That, of course, brought up the question of battery voltage. He did not know of any locomotive at present in which the battery was more than 350 volts or 400 volts, and if they were working with 1,500 volts on the overhead line some difficulties might arise.

Mr. G. S. Rose said he knew about 100 battery locomotives at present in use. One shipbuilding firm in Scotland bought one six years ago, and had ordered additional ones about every eighteen months since. Battery locomotives were also being used to a considerable extent in mines. In this case, of course, they were very small, the battery capacity being about 10 kw.-hours. With regard to the voltage of batteries, the concern with which he was associated was at present manufacturing two batteries for two locomotives, each to have 234 cells in series, and there were also two other batteries going through the works for one locomotive, each containing 116 cells, the ampere-hour capacity being 390. The kw.-hour capacity at the five-hour rate of discharge was 326 kw.-hours. He understood that this locomotive was to draw a brake train or an inspection train through an unventilated tunnel in New Zealand, the length of the tunnel being five miles, and the gradient 1 in 33. Mid-day boosting, or boosting at odd intervals, did not injure the batteries in any way, but such boosts should not be carried out long enough to bring the batteries up to full charge.

Sir Philip Dawson said when the longer distances of line were operated electrically, the question of wayside shunting would become more and more important, and except in the big shunting yards, battery locomotives would be extremely useful. The question of how to charge a battery locomotive from a 1,500-volt line was an important one, and would have to be taken into consideration in discussing the whole question of railway electrification.

Mr. Elliott, speaking with regard to the open type cell for locomotives, said he knew of two locomotives which were running without lids to the batteries, and although the freeboard was only about 1 in. or 1½ in., the engineer asserted that no acid was spilled. In the ordinary type of cell for locomotives, a lid was usually provided. As to the life of cells, the locomotives to which he had referred, which were running in Switzerland, had been in use for thirteen years, and were fitted with a Planté type of cell. The first set of batteries lasted for seven or eight years, and the second one was still in existence. He did not think any light type of cell would have lasted that time.

Mr. Edwards asked if anything had been done with regeneration, so that the energy absorbed in braking could be utilised for charging up the batteries. If that were practicable, battery locomotives would have a very much wider application.

Colonel Cortez Leigh was not at all in agreement with the author about using battery locomotives on branches and off-sidings. The equipment of these lines was not a very expensive matter, and it seemed a more efficient way of doing the work. He thought that Exide or Edison batteries were more suitable than the Planté. Railway locomotives of this nature were very roughly handled in shunting yards. On this point he would like to ask the author whether he had had any trouble from the men operating these locomotives being asked to be put on the same basis as ordinary locomotive drivers, and also whether it was necessary, through labour conditions, to have more than one man on the locomotive?

As to the use of battery locomotives on branch lines, he had seen some vehicles at work in Hungary

before the war doing very good work. These were petrol-electric vehicles. They worked very economically, and he felt that in this country there was an opening for petrol-electric vehicles on railways which would answer the purpose to which battery locomotives were put, and especially for branch lines and sidings. He himself had such a vehicle, which was used occasionally for inspection purposes, and was found most economical. As to charging, he had carried out experiments with train electric lighting equipments, with charging at the terminal stations instead of carrying dynamos on the train, with satisfactory results. It was, of course, a short distance train, and at each end of the line there was a plugging arrangement through which the cells were charged.

Mr. W. Agnew said he did not think sufficient attention had been given in the discussion to the disappointing results with battery locomotives in regard to their speed. It had been suggested that at wayside stations main line locomotives could be utilised by attaching a tender containing storage batteries, but it must be remembered that main line locomotives were already very substantial in their construction, and to add a tender would unduly increase the weight. He did not think such an arrangement would be found satisfactory by the traffic department, on account of the low speed. With regard to the author's suggestion that a mid-day boost damaged the battery, he could not himself see why there should be any adverse results.

It might be of interest if he mentioned a locomotive which had been constructed to haul ballast trains, containing 18 or 20 ten-ton wagons, at night over the electrified lines at such times as the current was switched off. This had necessarily to be heavy because the battery was a very large one. The total weight was about 80 tons. The results were found to be unsatisfactory to the permanent-way department, because the locomotive was too slow. On the question of the drivers of battery locomotives, he had found that they expected to be dealt with as if they were driving steam shunting engines, and to be paid the same rates.

Mr. F. W. Carter suggested that the motors of battery locomotives might with advantage be compound wound instead of series wound, in order to enable them to be used for regeneration, and make the radius of the vehicle so much the greater. This would mean special control, but something of the sort had been done in connection with electric vehicles for roads, such as electric 'buses.

Mr. Bruffell referred to the use of locomotive tenders with batteries, following the main line engines. A main line engine weighed 100 tons or so, it if were to have a battery tender attached to it, it might in the aggregate weigh 200 tons, and that did not leave much margin for wagons. In any case, he thought the speed of the combination would be very low. Reference had been made to the efficiency of battery locomotives as being undesirably low. The author mentioned that it was 50 per cent., but he could not see how he got that figure.

In the paper it was stated that the input was double that of a conductor supplied locomotive, and if the author meant that the efficiency of the battery locomotive was 50 per cent. of the efficiency of the conductor locomotive, then it was only of the order of 25 per cent., which was not a very satisfactory result. The efficiency of the battery locomotive could be improved in two ways. The first was to alter the control to get rid of some of the rheostatic losses, and the second was by improving the cells. If the energy wasted in the brakes could be utilised a very great deal more work could be got out of the batteries.

The Chairman said that there were sections of the coal mines in America, where, owing to ventilation risk, battery locomotives were used on a large scale. They were not comparable with the battery locomotives required for moving heavy trains, but they had a capacity of approximately half that mentioned in the paper, *i.e.*, they had a weight of about 10 tons. The important feature was the battery, and he had hoped to hear more about it, because he felt that the development in this direction was in the hands of the battery makers.

Mr. Dalziel, in reply, said that with regard to branch-line working and sidings, he was not suggesting running main line locomotives, designed for 75 miles an hour, into wayside sidings, but there were a large number of sidings where a great deal of money would be saved if they could be dealt with without equipping them completely electrically. The shunting he was speaking of was done by wayside locomotives, which were not going to weigh anything like 100 tons, and there was no reason why they should not carry a tender behind, because they would probably have to carry a brake van in any case in order to keep the train in hand going down gradients.

Branch lines, unfortunately, presented many difficulties. They might start by equipping a branch line with battery locomotives, and they would be all right for 23 out of the 24 hours, but in the twenty-fourth hour a milk train came along, which was four times the usual weight, and they could not deal with a case like that with battery traction. Therefore, if they had to have a steam locomotive to deal with part of the work they might as well work the whole service by steam. There were a great many branch lines on the Continent being worked with electrically-equipped passenger vehicles with batteries underneath, and for cases like these, of which there were a great many instances in this country, battery traction would be very serviceable, and would save a great deal of money.

He saw no difficulty in charging from the overhead wire through a resistance, keeping the battery floating on the line at the normal voltage. In that way they should be able to do the lighter work of the sidings, where they were working at 600 volts on the overhead system. When working at 1,500 volts, however, the proposition became different and they would have to use a motor generator. It must be borne in mind that battery traction was no good whatever for heavy work. He was speaking in his paper of light work, which formed a very considerable proportion of railway work generally. As regards the capstan, as against the battery locomotive, he estimated that 10 capstans would cost to-day 6,000*l.* The interest on that amount of money, at 12 per cent., was nearly 800*l.*, and even at 10 per cent., which was low, it was 600*l.* The advantage of battery traction as against capstans was mainly in capital expenditure. As regards labour conditions, he had not found the slightest difficulty in getting the yard staff to work the locomotive and to charge it.

This concluded the discussion and the Section proceeded to the joint meeting with Section III, at which Sir Vincent Raven's paper on electric locomotives was discussed. With this paper and its discussion we have already dealt on page 138 of the present issue.

THE MOTOR TRADE TELEGRAM CODE.—The Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, S.W. 1, have issued, at the price of 42*s.* net, the above code, compiled by Mr. W. M. Saunders. It gives code words and code numbers to words and terms from A to Z, to dates, decimals, horse-power, &c., and examples to facilitate its use.

INSTITUTE OF METALS.—The following papers are expected to be submitted at the annual meeting of the Institute of Metals, to be held in Birmingham on September 21 to 23:—(1) Professor A. A. Read (Cardiff) and Mr. R. H. Greaves (Woolwich), on "The Properties of Some Nickel-Aluminium-Copper Alloys"; (2) Mr. R. T. Rolfe (Bedford), on "The Effect of Increasing Proportions of Lead upon the Properties of Admiralty Gun-Metal"; (3) Mr. R. Genders (Woolwich), note on "The Casting of Brass Ingots"; (4) Mr. T. G. Bamford (Birmingham), on "The Density of the Zinc-Copper Alloys"; (5) Mr. F. Johnson (Birmingham), on "Experiments in the Working and Annealing of Copper"; (6) Mr. W. E. Alkins (Manchester) and Mr. W. Cartwright (Buxton), on "The Effects of Progressive Cold-Drawing upon Some of the Physical Properties of Low-Tin Bronze"; (7) Mr. R. Genders (Woolwich), on "The Extrusion Defect"; (8) Mr. F. S. Tritton (Teddington), on "The Use of the Scleroscope on Light Specimens of Metals"; (9) Mr. D. H. Ingall (Birmingham), on "The Annealing of Rolled Zinc"; (10) Mr. D. Hanson (Teddington) and Miss M. L. V. Gayler, (Teddington), on "The Constitution and Age-Hardening of the Alloys of Aluminium with Magnesium and Silicon"; (11) Mr. F. Adcock (Sheffield), on "Electrolytic Etching of Metals"; (12) Mr. S. Beckinsale (London), note on "Electron" (the high magnesium alloy). Since the inaugural meeting of the Institute in Birmingham, in 1908, the membership has grown from 200 to over 1,300.

BOILER EXPLOSION AT A LONDON HOSPITAL.

A REPORT has just been issued by the Board of Trade, under the Boiler Explosions Act, 1882 and 1890, in regard to the circumstances and cause of a boiler explosion which occurred on February 2 last, at the Royal Chest Hospital, City-road, E.C., the boiler being the property of the trustees of the hospital. Two men, the engineer and a porter, were so severely scalded that they died shortly after. Two other men were injured, one being able to resume duty about a week after the occurrence and the other was expected to resume duty shortly.

The boiler, which was used for heating purposes, was of the vertical type, with an internal fire-box and central uptake. The shell was about 4 ft. in height and 3 ft. in internal diameter, the plates being $\frac{5}{8}$ in. in thickness. The fire-box was of steel, fitted with two cross-tubes, and there was a water space of 4 in. between the bottom and the end plate of the boiler. The flat surface at the bottom was supported by three screwed stays, 1 in. in diameter, spaced equally apart on a pitch circle of about 1 ft. $4\frac{1}{2}$ in., the ends being riveted over. Every seam in the boiler was fire-welded. Various fittings were attached to the boiler, particulars of which are given in the report which Mr. Longstaffe, surveyor, supplied to the Board of Trade on his examination made after the explosion. Suitable hand holes were provided for cleaning out the boiler and cross-tubes, and the report states that, according to the makers, the boiler was subjected to a hydraulic test of 100 lb. per square inch. The boiler was made by Messrs. Binns and Speight, of the Crown Boiler Works, Bradford, in 1912, and was therefore about nine years old. The mountings were fitted by Messrs. J. Wontner-Smith, Gray and Co., of London. No repairs had been carried out and the boiler had been inspected by the surveyors to the Vulcan Boiler and General Insurance Company annually since 1912. The last thorough examination was made on June 4, 1920, and it was again examined under working conditions on December 24, 1920. After both of these examinations the usual report in the form presented by the Factory and Workshops Acts, 1901 to 1911, was sent by the Insurance Company to the owners of the boiler, and the character of those reports indicated that the company was satisfied with the condition of the boiler and its mountings, and that no repairs were required. The insurance included re-instatement of the boiler and premises.

The explosion, Mr. Longstaffe states, was of a violent nature. The bottom end plate was torn completely away from the boiler through the welded circumferential seam, and the three screwed stays were drawn out of the bottom plate of the fire-box. The boiler was projected upwards a distance of about 8 ft., striking some beams supporting the floor of the room immediately above the boiler houses. These were badly bent and torn from their supports. The flow and return pipe connections were fractured and the relief valve was broken off the boiler, apparently through contact with the beams, and was subsequently found in pieces under the *debris*. The whole of the water in the system escaped through the broken pipes into the boiler-house.

The explosion was primarily due to the generation of excessive pressure in the boiler consequent upon the fire being lit in the boiler with all outlets closed and the relief valve inoperative. The violence of the explosion, following on the failure of the seam, was occasioned by the sudden release of the energy stored in the water by being heated under pressure.

The report proceeds to say that the boiler which exploded was known as No. 1, and was one of two similar boilers used for heating water for the baths and lavatories in the hospital. Each was fitted with shut-off valves to the flow and return pipes of the system so as to enable either boiler to be isolated for cleaning purposes or inspection. Under normal working conditions the pressure to which the boilers were subjected was only that equal to the head of water due to the height of the open feed tank, which was about 51 ft. One of the employees of the firm of heating engineers who had regularly carried out the work at the hospital for some years, was instructed to clean out No. 1 boiler on January 24. On his arrival at the boiler house after ascertaining that both flow and return valves were shut, he unscrewed the relief valve bodily from the short pipe into which it was fitted so as to admit air; he then emptied the boiler by opening the blow-off cock on the bottom of the shell, and after removing the necessary inspection doors he proceeded to clean out the boiler. On completion of this work he remade the joints on the various doors and then opened the return valve and allowed the water from the system to flow into the boiler until it escaped freely through the relief valve orifice. He then replaced the relief valve and afterwards opened the flow valve, situated on the crown plate, to release any air which might be trapped in the pipe connection to the valve. On the instructions of the engineer to the hospital he then shut both flow and return valves tight; thus the boiler was left full of water and isolated. He states that the relief valve mounting, with the exception of removing and replacing it, was not interfered with in any way, and the broken pieces, when found after the explosion, appear to bear out his statement.

On February 1, a porter named Swanton was left in charge: No. 2 boiler was then being worked: No. 1 was, as previously stated, isolated. On February 2, another porter, James Crook, found Swanton in the boiler-house and Swanton told him that when banking up the fire in No. 2 boiler during the night a portion of the fire-door had broken off, and as he had difficulty owing to the impaired draught in maintaining the water

at the proper temperature, he had lit up No. 1 boiler about 7 a.m. Crook then noticed that there was a heavy fire in No. 1 boiler, and he told Swanton that he had done wrong in doing so without receiving instructions from the engineer. Crook states that he then pushed the damper partly in and left the boiler-house. Another porter, Walter Penfold, stated that he met Swanton outside the boiler-house and Swanton told him what he had done, and Penfold went into the boiler-house with him. Swanton appeared very uneasy, probably realising that he had exceeded his duty in lighting up No. 1 boiler without proper instructions. Penfold felt the body of the flow valve and found that it was very hot on one side and cold on the other; This he estimates would be about 5 minutes to 8. He advised Stanton to draw the fire, and he would go and hurry up Robinson, the engineer, who was then almost due to come on duty. He left Swanton drawing the fire, and met Robinson, who was on his way, and told him what had happened, and they both hurried to the boiler-house. On their arrival, Robinson, who had apparently realised that the valves were hard shut down, sent Penfold to the workshop for his "grips." He handed these to Robinson, who sent him back for a screw spanner. Penfold again went to the workshop, which is opposite to the boiler-house, and when returning with the spanner the explosion took place, the force of which knocked him down and rendered him unconscious. Robinson and Swanton were found in the boiler-house unconscious and suffering from severe scalds. They were removed to St. Bartholomew's hospital, where they subsequently succumbed to their injuries without making any statement. Another porter was thrown down, and was treated for his injuries on the premises.

The report goes on to say that Mr. Bays, a director of Messrs. Wontner-Smith, Gray and Co., proceeded to the hospital, and after viewing the wreckage he instructed his employees to remove the *debris* from the flow and return valves, which were broken off and lying under the fallen brickwork, &c. He found both spindles badly bent. He stated that after hearing particulars he expected to find both valves shut, and therefore sent for the secretary of the hospital to witness if his surmise was correct. On the secretary's arrival, he tried both valves with a wheel spanner and found them shut, and he afterwards opened the flow valve partly, as he says "to prove that the valve had been shut."

Mr. Longstaffe adds that he made an examination the day after the explosion. He examined the seam which failed, and the weld on the whole seemed to have been originally sound, with the exception of one or two places which were slightly defective, but it appeared to have been good enough for the pressure for which the boiler was intended. The fact of the end plate being dished outwards points to the probability that the stays drew out of the fire-box in the first place, and thus allowed the pressure on the whole flat surface of the end plate to be taken by the welded circumferential seam, which subsequently failed. When picked up, the relief valve was not hard down on the seat, being open about $\frac{1}{16}$ in., but the wings of the valve were jammed in the seat and it took considerable force to push the valve out. On examination of the bore of the seat, the impressions of the wings of the valve were found scored in the metal, indicating that the valve had been tight on the wings. The opening from the boiler was quite free from obstruction.

Mr. Beckett, one of the surveyors to the Vulcan Boiler Insurance Company, stated that he made a thorough examination of the boiler on June 4, 1920, and it was then, so far as he could ascertain, in good order. The relief valve had been taken adrift before he arrived, and he stated that he turned the valve round in its seat and found it free. He did not afterwards see the valve adjusted. He made a further examination of the boiler on December 24, 1920, under working conditions, but did not try the relief valve, as there was no easing gear fitted. The valve was loaded to 35 lb. per square inch, and there was only the pressure due to the usual head of water in the system, which he estimated at about 22 lb. per square inch. Both Crook and Penfold, in their evidence, stated that the relief valve was not blowing shortly previous to the explosion, nor even leaking, nor had they ever seen it lift. Had the valve lifted or even leaked, they could not have failed to have observed it, as, owing to its position on the boiler, it was on about the same level as their faces. If the valve had been blowing freely it would have prevented anyone from approaching the boiler within 2 ft. or 3 ft.

Mr. Longstaffe closes his report as follows:—

"Mr. Robinson, the engineer, and Swanton, the night porter, who would have been the two principal witnesses, are unfortunately dead, but reviewing the evidence given above of the incidents leading up to the explosion, it seems clear that the conditions existing were such as would produce over pressure in the case of the relief valve being inoperative. When, on the advice of Penfold, Swanton drew the fire there would be a further increase of pressure due to a temporary rise in temperature occasioned by this operation, and the failure of the stays at this time probably accounted for the explosion occurring very shortly after the withdrawal of the fire. Under ordinary working conditions the relief valve would never lift, as it was loaded to 35 lb. per square inch, and the greatest pressure that could be obtained in the boiler would be about 22 lb. per square inch, due to the head of water from the open feed tank. In these circumstances it would appear necessary that where boilers of this type can be isolated, as in this case, the relief valves should be fitted with easing gear, or so constructed as to enable the valve to be tried at frequent intervals so as to ensure that it was free to lift and in good order.

After the explosion No. 2 boiler was subjected to a hydraulic test of 55 lb. per square inch without showing any deformation; a slight leakage was, however, observed round the heads of the screwed stays in the fire-box.

"The stays have now been renewed with nuts on each end, instead of being riveted as originally fitted. The spring-loaded relief valve has also been replaced by one of the deadweight type."

Mr. Thomas Carlton, chief engineer to the Marine Department, makes the following observations in sending the surveyor's report to the Assistant Secretary:—

"The boiler appears to have been of sufficient strength for the pressure of ordinary working conditions, and to bring about its failure in the violent manner described in the report, there must have been present a pressure considerably in excess of that to which the relief valve was said to have been set. Had the relief valve been operative, there is a strong possibility that the explosion would have been averted, but the valve not being fitted, as it was very desirable it should have been, with means by which it could be eased and kept free to move, had apparently become fixed in its seat and so failed to act when required. Moreover, it had apparently not received proper periodical attention or it would not have been set fast.

"The unfortunate man, who by firing the boiler with all its outlets closed, brought about the explosion, may, in doing so, have exceeded his duty; but it should be said of him that he had apparently not been sufficiently instructed in that part of his duties, and was consequently unable, in the absence of the responsible engineer, to deal adequately with what was really a simple emergency. The engineer, when called upon, acted promptly, and it was only through lack of time that his efforts to prevent an explosion failed; but, as pointed out above, had the safety valve been in proper working order, this explosion would not in all probability have occurred, and it draws attention once more to the dangers arising from insufficient and defective arrangements. The protection afforded by such appliances amply justifies the comparatively small expenditure incurred in their installation, and the care and trouble required for their proper maintenance.

"The loss of two lives was an unfortunate consequence of the explosion."

COLLEGE TRAINING AND THE MANAGEMENT OF STEAM PLANT.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been drawn to the remarks made on page 67 of your issue of July 8, by "Mr. F. C. Lea." As evidently some of my friends are thinking that the opinion expressed by the speaker as reported by you are my opinions, I should be glad of the opportunity of stating that I should not agree with my namesake's final conclusion. With him and other speakers, I strongly hold that great economy and increased efficiency of fuel in boiler use, can be obtained by proper supervision. For example, I have known of several cases where trained supervisors have been given the duty of checking the methods of stoking and the composition of the exhaust gases in boiler houses, and this has resulted in very substantial economy. Mr. Lea goes on to say, however, that "No college or technical school taught the proper running and maintenance of plant, they confined themselves to more abstract and theoretical aspects of engineering." The kind of training that is given in engineering courses, supplemented always with that necessary common sense that an engineer dealing with men requires, can in addition do a great deal towards leading to economy in connection with coal and steam consumption. It is very frequently, I am convinced, in the direction of effecting these economies, that the more practical man fails. The final economy can only really be effected by treating the problem of coal consumption as a scientific problem, which requires scientific control and supervision.

I would suggest to those who have the management of large power plant units, what may appear to be somewhat courageous, and that they take young fellows who have not long completed their university course, and give them an opportunity in the boiler house of making a detailed examination of the stoking and the exhaust gases, and sufficient authority so that the stoking can be directed to the one end of economising fuel.

My own opinion is that the man who will accomplish the most will be not the so-called practical man, but the man who will treat this problem as a scientific problem, and who thus must have been trained in scientific methods at one of our technical colleges and universities.

Yours truly,
F. C. LEA.

The University, University-road, Edgbaston,
Birmingham, July 15, 1921.

THE EXISTING PRACTICE OF INSPECTING WORK AND MATERIAL.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the report of the discussion at the recent Engineering Congress, on "The Existing Practice of Inspecting Work and Material," appearing on page 111 of last week's (July 15) issue of ENGINEERING, I beg (once again) to be allowed to take up a little of your valuable space with a few comments on the above subject, from the point of view of a practical inspector of forgings, castings and component parts.

Personally, I think the most efficient inspection is done in our leading motor car and aeroplane factories. Commencing from the rough stores, where the castings and forgings are inspected, before being despatched to the machine shop.

Castings are closely inspected for cracks, sufficiency of metal, displacement of bosses, &c. Forgings undergo a similar process, with the following addition, viz.: Should the forgings be bent or twisted, they can be stretched to bring them fairly true, so that the turner, planer, or miller, &c., can machine them without various alterations to the setting of his machine. This method of inspection saves scrap and time.

Then we come to the machine shop, with its various sections. Each section has an inspector, whose duties comprise inspecting the first part machined from each machine in his particular section. This is followed up by an inspection of at least 10 per cent. of the work done by each machine, or as often as the inspector can possibly get round to the various machines.

This process of inspection is called operation inspection. Some firms have a final operation inspector at the end of each section to inspect the whole of the machined parts before passing on to the next operation.

This method entails having a large inspection staff (non-productive admittedly) but if the men are efficient inspectors, a lot of time, material and money is saved by scrapping faulty machinery and other defective parts before further machining is done to them.

The final inspection is, of course, the finished machined article.

Now, as Mr. Mannaberg states (although I think he was referring chiefly to the civil engineering side of inspection —steel testing by metallurgical processes) in the final inspection, a certain amount of overlapping would occur, if either the operation or final inspector were incompetent. That is to say, the part the operation inspector passed as "O.K." the final inspector would probably scrap.

This, I think, is what Mr. Mannaberg, referred to re the testing and inspecting of steel. Thus, one inspector may inspect steel for durability, strength, specification thicknesses, cracks, hard spots, &c., another may overlook one of the above, thereby passing inferior material.

Mr. Short's suggestion of a standard specification for steel would greatly facilitate the production of the same, especially for steel plates used in shipbuilding.

Replacements could then be made at any time without ships having to lay in docks (perhaps for a considerable period) through the particular specification of steel not being available at the required time.

I think a new era in engineering is near at hand, when engineering firms of every description will realise that a thoroughly organised inspection staff of efficient men would greatly aid and add to the engineering industry.

Yours faithfully,
T. W. ELLERTON.

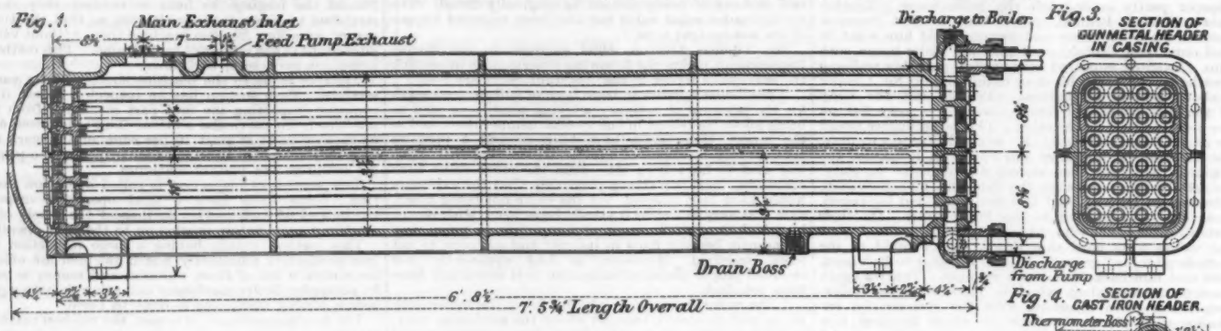
"Richmond Villa," 68, Sale-street, Derby,
July 18, 1921.

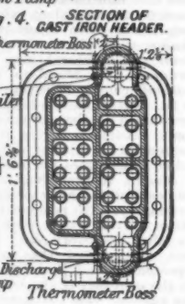
LIQUID COLLOIDAL AND POWDERED FUEL: ERRATUM.—In our report of the discussion on this subject at the summer meeting of the Institution of Mechanical Engineers, we stated, on page 90 of our issue of the 15th inst., dealing with the remarks of Mr. P. V. Vernon in connection with the use of coal dust, that "on injecting 0·7 per cent. of paraffin (reckoned on the weight of coal), together with the coal, the clinker became good, but the flame darkened again as soon as the oil was turned off." The actual amount of paraffin used with the coal dust was, however, 0·07 per cent.

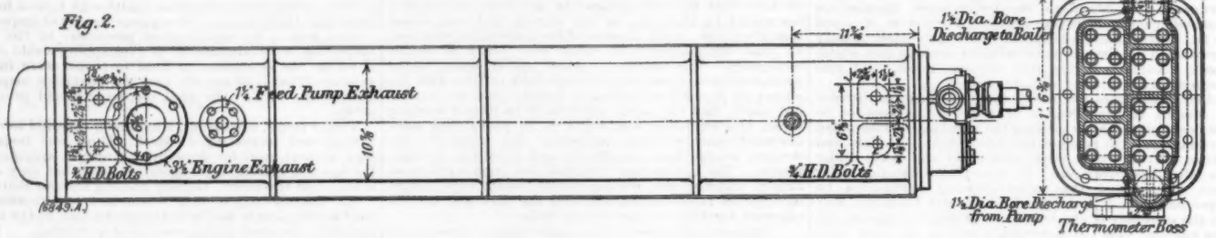
FRACTURES OF BRONZE AND IRON BELL CLAPPERS.—Some failures of church-bell clappers induced J. Grimme, of the Bochumer Verein für Gusstahlfabrikation, to experiment on the behaviour of steel rods under conditions similar to those to which a bell tongue would be exposed. He observed that many of the specimens broke, although quite sound near the fracture, in a way for which an adequate explanation has not yet been found. He suspended his rods between two blocks of cast-iron which the rod would strike when deflected 45 deg. to the right or left. The suspension was by means of a leather loop fastened in the first series of tests round screw bolts fitted into the upper forked end of the rod. Most of the rods were club-shaped, thickening towards the bottom. The first rods broke across or near the bolt holes, after 90 hours, corresponding to 185,000 double blows. When the bolts were replaced by cast-on lugs, the fracture occurred after longer service, 220 hours, and lower down, near the point where the rod began to thicken. The material was superior mild steel: an exceptionally good nickel steel lasted longer, but broke too, finally. The well-known experts, C. von Bach and Baumann, whom Grimme consulted, both suggested that it would be more advisable to reduce the cross-section in the middle portion of the rod than to increase the section. Long flat rods, not specially weighted at the bottom, were then tried. They lasted 500 hours, but when a small indentation, about 0·5 mm. deep, was made nearly halfway down the rod, with the aid of chisel, the rod broke across at that spot on further experimenting. Then a kind of flat bar pendulum was used, oscillating with its greatest section at right angles to the direction of motion; this also lasted more than 500 hours, but then developed a crack on the one side, half-way down. Baumann recommended this shape, *i.e.*, a clapper with a long, relatively thin and yielding shaft. One would think the failure would be due to resonance effects; but the mode of operating the clappers is not sufficiently clearly explained in the *Zeitschrift des Vereines Deutscher Ingenieure* of June 8 last, to express any definite opinion. The fractures did not indicate any deformation or flow of the materials, nor any want of homogeneity. The tests are severe, of course.

FEED-WATER HEATER AND PUMP FOR LOCOMOTIVES.

CONSTRUCTED BY MESSRS. G. AND J. WEIR, LIMITED, ENGINEERS, CATHCART, GLASGOW.







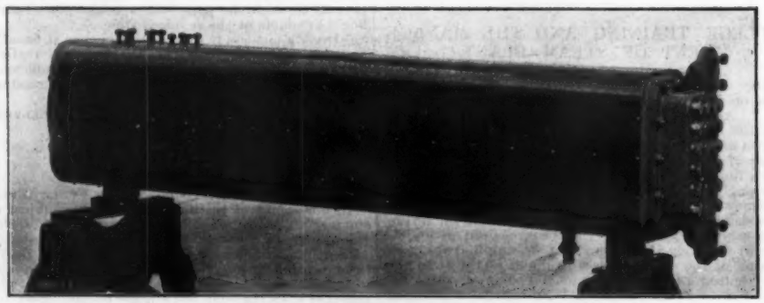


FIG. 5.

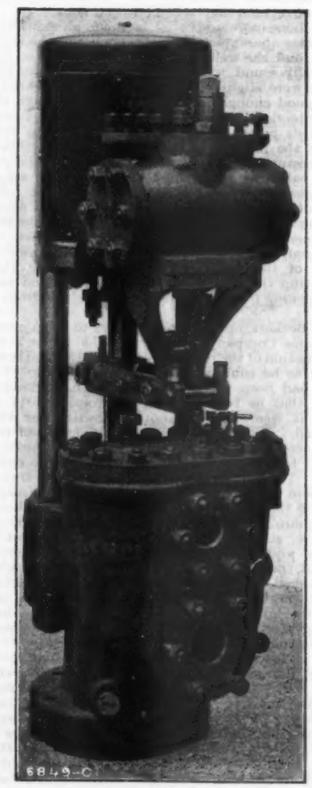


FIG. 8.

WE have from time to time described in our columns the progress made by feed-water heating on locomotives and have dealt with different methods adopted in its application. Many of our readers will no doubt be aware that Messrs. G. and J. Weir, Limited, of Cathcart, early took up the subject, and have now built feed heaters and pumps suitable for locomotive work, for something like ten years, during which time substantial developments have taken place. The system adopted by Messrs. Weir is that of exhaust heating only, with a surface heater, a pump being employed to force the feed through the heater and into the boiler. The necessary exhaust is drawn off through a branch pipe from the blast pipe or exhaust cavity in the cylinder casting, the pump exhaust, of course, also being turned into the heater.

In Figs. 1 to 8 annexed we illustrate the main parts of the Weir feed-heating system for locomotives as now in use. Figs. 1 to 5 show the heater, the design of which will be readily followed from the drawings. The heater consists of a cast-iron body or shell, containing 24 copper tubes. At one end, shown to the right in Figs. 1 and 2, and in section in Fig. 4, is a cast-iron header into which these tubes are expanded. This header is bolted to the shell. It will be seen to have a vertical partition, and other horizontal partition walls, which divide the tubes into several groups. The other ends of the tubes are expanded into a gunmetal header which fits inside the casing (Figs. 1 and 3). The latter header is divided by horizontal partitions, the combination of the arrangements at the two ends being such that the feed entering from the pump, passes to and fro' 12 times in the heater through different sets of tubes, before leaving to pass to the boiler. The inside header is free to move in the heater and so takes care of the expansion and contraction which has always formed one of the troubles of small heaters of the surface type. Screwed brass plugs are arranged in both headers opposite the tube ends, so that the tubes can be readily inspected and cleaned, while the whole of the tube element, complete with headers can be very easily withdrawn. The feed connections are made with cone joints.

FIG. 6.

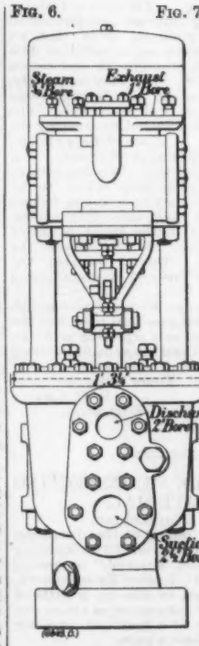
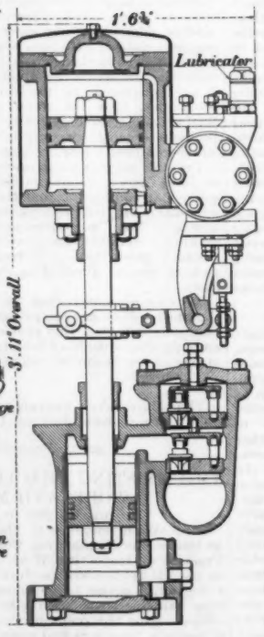


FIG. 7.

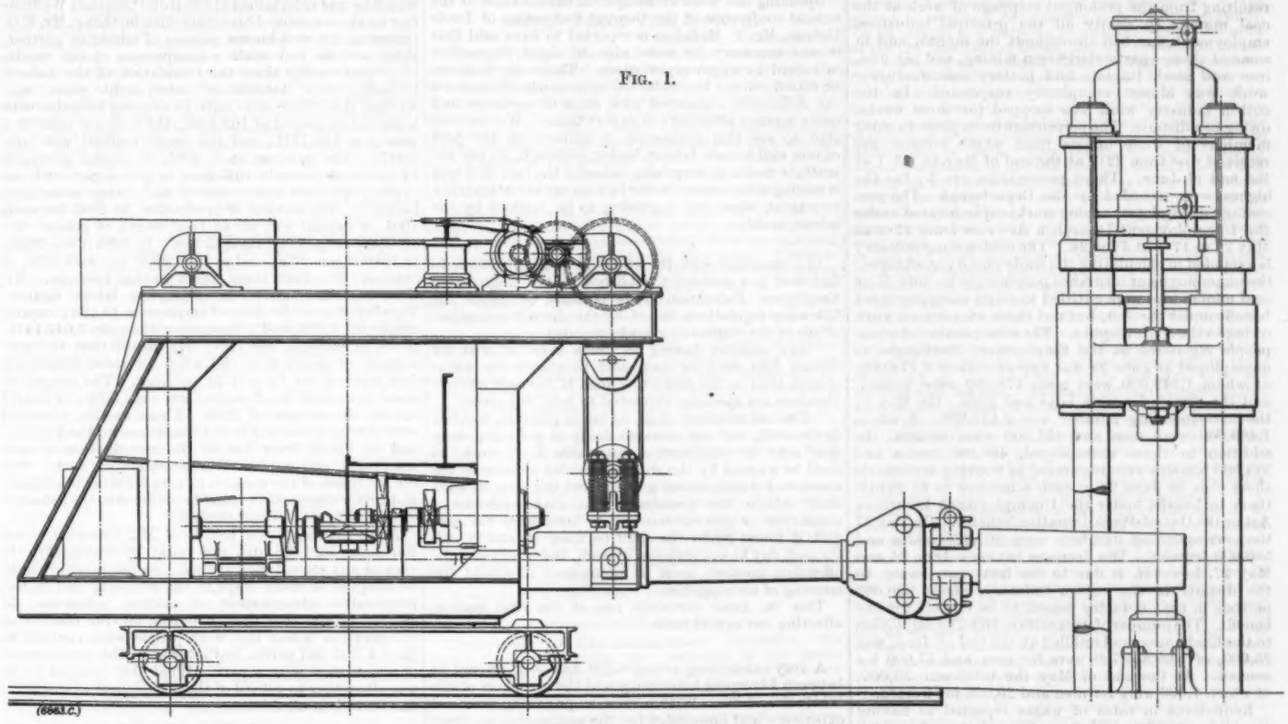


The pump is of the vertical double-acting type, and embodies all the essential features of the Weir marine feed pump. The steam distribution to the cylinder enables it to cover a very wide range. It will operate from one stroke in five minutes up to about 29 double strokes in ordinary working. It is possible to run at higher speeds than this, but considerations of economy in upkeep show that if greater capacity be required a larger pump should be used. The installation is made in standard sizes up to a capacity of 55,000 lb. per hour. The pump shown has a normal capacity of 16,500 lb. per hour, and has a water end 5½ in. in diameter by

MECHANICAL MANIPULATOR FOR HEAVY FORGINGS.

CONSTRUCTED BY THE ALLIANCE MACHINE COMPANY, ENGINEERS, ALLIANCE, OHIO, U.S.A.

FIG. 1.



6 in. stroke. The feed is finally delivered to the boiler through a spring-loaded spray valve in the steam space. The cost of the installation is such that it is claimed that the economy shown will easily cover the extra expenditure in two years.

It is interesting to note that Messrs. Weir who have thus adopted surface heaters for locomotive work, are strong advocates of direct-contact heaters for marine work. The former they consider to have considerable advantages for locomotive work, especially in the direction of simplification and flexibility. With regular attention, and care in design a high efficiency for a tubular heater may be easily maintained in locomotive work.

MANIPULATORS FOR HEAVY FORGINGS.

In order to keep pace with the speed of modern forging presses and to reduce the amount of arduous manual labour in heavy forges, it has been found desirable to introduce special machinery of various kinds to manipulate the work under the presses. The illustrations above and on page 154 show two such machines, constructed by the Alliance Machine Company of Alliance, Ohio, U.S.A. The first of these, illustrated in outline in Fig. 1, annexed, and of which the general appearance will be better understood from Fig. 3, on page 154, is a machine of the class which is known as the universal ground type, with a rated capacity of 5 tons. Machines of the same type are built for dealing with work ranging from 2 tons to 20 tons. The carriage is arranged for slewing and the porter bar is provided with lifting, lowering and rotating movements, thus enabling all necessary manipulation of the work under the press to be performed. To operate a forging press of the Davy type working in conjunction with such a manipulator only three men are required, namely, one press operator, one manipulator driver and one handy man, so that the labour costs are considerably reduced in comparison with average British and Continental practice. A 1,000-ton press, served by a manipulator, and worked with the above-mentioned crew, is stated to have regularly cogged down 100 tons of 3-ton ingots in an 8-hour shift; the ingots, which were 18 in. square, were reduced under the press to blooms measuring 9 in. by 10 in. for feeding a billet mill. The cogged blooms were cut up into 5-ft. to 6-ft. lengths under the press and transported to the reheating furnace by means of a roller gear arranged at the discharge side of the press.

All the movements of the manipulator are operated by electric motors with the exception of the grippers, which are actuated by an air-piston taking its air from a self-contained compressor and receiver carried on the machine. This pneumatic grip has been found by the makers to be much superior to the screw-operated grip, as it is free from the liability of sticking. All controls are within easy reach of the operator, who stands on a platform which commands a view of the work. In case of an overload being brought to bear on the machine by the press, the manipulator arm is enabled to deflect by means of the suspension springs and the balance weights attached to its tail end. The gripping tongs are made readily removable so that they can be quickly changed when others of a special form are required for any particular work.

The smaller machine, illustrated in Fig. 2, is of 2 tons capacity, although the same type is constructed to deal with work up to 5 tons. The machine has no slewing motion, as it is arranged to work on a radius track on the floor. It is, however, provided with a separate carriage to permit of longitudinal traverse of the porter bar. The latter can be rotated by means of a motor and gearing mounted directly above the bar near the fulcrum pin, as shown in the illustration. The bar-lifting mechanism is provided with slipping gear to avoid any possibility of damage to the machine should the load of the press be accidentally brought to bear upon it.

Manipulators of the types illustrated are in use in the United States in conjunction with high-speed Davy forging presses, the combination enabling very rapid and economical working. The Alliance Company build machines somewhat similar to that shown in Fig. 2, but fitted with independent slewing mechanism when the manipulator has to work on a straight track. The type is also modified so as to work from overhead supports, when an unobstructed floor space is necessary.

In addition to the reduction of labour costs and the fuller advantage which can be taken of the capacity of the forging presses, the use of manipulators reduces the number of heats required on account of the greater speed of working. These machines also provide an economical means of cogging down steel ingots where the output does not warrant the outlay on an expensive cogging mill plant. Messrs. Davy Brothers, Limited, of Park Iron Works, Sheffield, have made arrangements through Messrs. Stothert and Pitt, Limited, of Bath (the European manufacturers for the Alliance Machine Company) for the supply of these machines for forging installations in Great Britain and abroad.

SPANISH MINING AND INDUSTRIES DIRECTORY.—The twenty-first annual edition of this directory, for the current year has now appeared. Its title is *Anuario de Mineria, Metalurgia Electricidad y demas Industrias de España*, and it is published by the *Revista Minera, Metalúrgica y de Ingeniería*, Madrid, at the price of 10·50 pesetas, including postage. It gives particulars of all the Spanish mines classified under materials and provinces, also data on the mining, metallurgical, engineering, electrical and chemical societies established in Spain, directory of engineers, &c. It quotes the fees for tests and analyses in various Spanish laboratories. The address of the above-mentioned publishers is Villalar 3, Madrid.

THE DREDGER GUNGA.—The Gunga, launched on the 7th inst. by Messrs. William Simons and Co., Limited, to the order of the Commissioners for the Port of Calcutta, is the largest dredger yet built on the Clyde, and is the third dredger built by Messrs. Simons for the improvement and maintenance of the River Hooghly. She measures 370 ft. in length by 57 ft. 6 in. by 24 ft. 6 in., and has a hopper capacity of 80,000 cub. ft. The suction pipe is arranged to dredge to a depth of 45 ft., and is designed with a trunnion at each end of the well so that dredging can be done when the vessel is propelling either ahead or astern. Or, alternatively, dredging can be done while the vessel is moored to anchors either ahead or astern. The "Simons" patent sand baffling arrangement is provided, an arrangement which has proved most effective in its action in reducing the loss in overflow to the minimum. The hull and machinery are constructed to Lloyd's highest class. The propelling and pumping engines are placed in two independent compartments. The propelling power is supplied by two sets of triple-expansion surface condensing engines, the machinery including steam and hydraulic reversing gear, steam turning gear, independent circulating pumps, automatic feed pumps, feed heaters and filters, large evaporators for feed-water make up, and a complete outfit of auxiliary feed and bilge pumps. Steam is generated by four large single-ended horizontal multitubular boilers, constructed to Lloyd's rules for a working pressure of 180 lb. The pumping outfit, placed forward of the hopper in an independent engine-room, consists of one set of triple-expansion engines, with independent condensing plant and circulating pumps, complete with all modern fittings. The pump engines are coupled direct to a centrifugal sand pump specially designed to raise and discharge about 5,000 tons of sand and silt per hour. The pump is connected to a suction pipe placed in a well at the fore end of the vessel, being fitted at the upper end with a massive swivel bend, which serves as a trunnion or hinge upon which the pipe is free to move vertically. The suction end of the pipe is fitted with a specially-designed drag nozzle to suit the character of the material to be dredged, while a grid is also fitted to the nozzle to exclude material which might choke or damage the pump. The suction pipe is controlled by a steam winch placed on deck. The Gunga has been constructed under the direction of Mr. J. Angus, M.Inst.C.E., engineer and London agent to the Calcutta Port Commissioners.

INDUSTRIAL NOTES.

ACCORDING to information issued by the Ministry of Labour, there was a further decline in employment during June owing to the increasing scarcity of fuel resulting from the prolonged stoppage of work at the coal mines. In nearly all the principal industries employment was bad throughout the month, and in some of them—particularly iron mining, and pig-iron, iron and steel, tinplate and pottery manufacture—work was almost completely suspended. In the cotton industry work was stopped for three weeks, owing to a dispute. The percentage unemployed among members of trade unions from which returns are received rose from 22·2 at the end of May to 23·1 at the end of June. These percentages are by far the highest ever recorded by the Department. The percentage unemployed among workpeople insured under the Unemployment Insurance Act rose from 17·3 at May 27 to 17·8 at June 24. The coal-mining industry is excluded in calculating the trade union percentages; the unemployment insurance percentages include those coal miners who were entitled to claim unemployment benefit under the Act, but not those who ceased work owing to the trade dispute. The total number of workpeople registered at the Employment Exchanges as unemployed at June 24 was approximately 2,178,000, of whom 1,549,000 were men, 478,000 were women, and the remainder were boys and girls. On May 27 the corresponding number was 2,122,000, of whom 1,469,000 were men and 497,000 were women. In addition to those unemployed, 490,000 males and 343,000 females were registered as working systematic short time on June 24 in such a manner as to entitle them to benefit under the Unemployment Insurance Act or the Out-of-Work Donation Scheme. On May 27 the corresponding numbers were 607,000 males and 580,000 females. The decrease between June 24 and May 27, however, is due to the fact that, owing to the dispute in the cotton industry, about 320,000 persons in that industry ceased to be eligible for the benefit. The number of vacancies notified by employers to the Exchanges, and unfilled at the end of June, was 25,000, of which 5,700 were for men and 17,000 for women. At the end of May the total was 30,000, of which 7,000 were for men and 20,000 for women.

Reductions in rates of wages reported as having come into operation in June, in the industries for which statistics are compiled by the department, affected about 1,060,000 workpeople. The number affected by increases in rates of wages was only about 14,000. The net effect of all these changes was a reduction in weekly full-time wages amounting to nearly 420,000*l.* The principal groups of workpeople affected included cotton operatives, who sustained a reduction amounting in most cases to 60 per cent. on list prices, equivalent to about 19 per cent. on current wages; men in the shipbuilding and ship-repairing industry, whose rates of wages were reduced by a second instalment of 3*s.* a week on time rates and 7½ per cent. on piece rates; and hosiery workers in the Midlands, whose bonus of 1*s.* 1*d.* in the shilling on earnings was reduced to 1*s.* Other important bodies of workpeople whose rates of wages were reduced included iron and steel workers in the Midlands, furniture trade operatives in London, Liverpool, High Wycombe and some other places, vehicle builders in the North of England and in the Midlands, and paint, colour and varnish workers. Since the beginning of 1921, changes in rates of wages reported to the Department have resulted in a reduction of about 1,770,000*l.* in the full-time weekly wages of over 4,300,000 workpeople, and an increase of 83,000*l.* in the full-time weekly wages of 350,000 workpeople.

The number of trade disputes, involving stoppages of work, reported to the department as beginning in June, was 29. The most important of these was the dispute in the cotton industry. In addition, 62 disputes which began before June were still in progress at the beginning of that month. The total number of workpeople involved in all disputes in progress in June (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 1,535,000, as compared with 1,152,000 in the previous month, and 128,000 in June, 1920. The estimated aggregate duration of all disputes during the month was nearly 30,000,000 working days, as compared with 23,200,000 days in May, 1921, and 1,200,000 days in June, 1920. The exceptional magnitude of the figures for May and June, 1921, is due to the stoppage involving coal miners throughout the country, which began on April 1 and was not ended until July 1. The estimated aggregate duration of all disputes reported during the first six months of the present year was approximately 77,000,000 working days.

On July 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel and light, and miscellaneous items) was 119 per cent. above that of July, 1914. This figure is the same as that for June 1, decreases in the prices of some articles having been counterbalanced by increases in the prices of others.

Speaking last week at Bangor on the occasion of the annual conference of the General Federation of Trade Unions, Mr. T. Mallalieu is reported to have said that it was necessary for some men to assert themselves in regard to wages negotiations. Those negotiations, he stated, should be conducted by men who understood the difficulties connected with rates of exchange and other matters affecting our export trade. We are very glad to see this expression of opinion on the part of one well-known labour leader, although, to say the truth, it would be surprising indeed if the fact that ruin is staring this country in the face owing to our inability to export were not beginning to be realised by the labour world.

In connection with the above it is disappointing to find that in a statement published by the Engineering Employers' Federation it is possible to quote the following regulations issued by the district committee of one of the engineering trade unions:—

"Any member having so much time allowed for certain jobs shall be compelled to absorb the whole of such time on the task or be fined 1*l.* for each offence. Members are specially requested to note this clause.

"That all members shall, as far as possible, do a fair day's work, and any member doing or enforcing more than may be considered a reasonable day's work he shall be warned by the shop committee witnessing the same, and if such warning be ignored the shop steward shall inform the president, who shall authorise a committee or general meeting to investigate the case and, if found guilty, he shall be fined 1*l.* and 2*s.* 6*d.* for each day he so continues to work, but in all cases the offending member must be summoned to attend the meeting of investigation."

This is, most certainly, one of the vital matters affecting our export trade.

A very interesting arrangement has been arrived at between Liverpool University and the managers of the White Star Line. With a view to providing practical experience and knowledge for the engineering students of the University, the managers of the White Star Line have decided, after consultation with the chairman of the company (Mr. Harold A. Sanderson), to give facilities to students of the University, through the Liverpool Engineering Society, for obtaining experience at sea during their vacations. The scheme will be of great value to students from the point of view of the practical experience they will gain; it has been drawn up by Mr. W. J. Willet Bruce, O.B.E., superintendent engineer of the line. The first student goes as a supplementary engineer on the R.M.S. Baltic. The scheme provides that one student joins each of the steamers of the line sailing from Liverpool between the 16th inst. and October 5. The students will either take watch with the other engineers or their duties will be arranged to give them experience in dealing with certain auxiliaries, and also in the running of engines and boilers. They will learn the various duties which engineers have to perform in the engine-room and boiler-room and take part in overhauling deck machinery. They will thus gain knowledge and experience which they could never derive from any engineering works ashore.

Last Monday, cotton operatives to the number of about 150,000 in the Lancashire spinning mills commenced working longer hours. The larger section—the American section—increased their week from 24 hours to 35 hours, and the Egyptian section from 35 hours to 48 hours. The former had been on a 24-hour week for seven months, and the latter on a 35-hour week for nine months.

It is reported that a compromise has been reached in regard to the application of the employers for a reduction by two instalments of the dockers' minimum wage of 16*s.* per day to 12*s.*, which latter figure the men refused to agree to. Both parties have now agreed that there shall be on and after August 4 a reduction of 2*s.* per day, followed by another reduction of 1*s.* per day to take effect as from January 5, 1922.

Messrs. Vickers, Limited, have posted a notice at their Naval Construction Works, Barrow, to the effect that owing to the continuance of the woodworkers' dispute the works will close from to-day down to August 9. The woodworkers or ship joiners have been out since December 1 of last year, as we reported at the time; they have found work at their trade in other directions. Since the dispute started a number of ships have had to be dispatched to Continental yards for completion, and others are being greatly delayed in British yards.

In the course of a speech he made at a luncheon at which he was entertained at the Hotel Cecil last Wednesday on the occasion of his eighty-fifth birthday, Mr. E.O. Greening, the well-known pioneer of labour co-partnership, said he had made a comparison of the results of co-partnership since the foundation of the Labour Co-partnership Association thirty-eight years ago. At that time there were only 15 existing societies with a capital employed of 103,436*l.*, the business done in a year was 160,751*l.*, and the profit realised was only 8,917*l.* The gain on each 100*l.* of capital averaged 8¼ per cent., merely sufficient to pay 5 per cent. on capital, provide some reserve and carry something forward. The output or production in 1883 for each 100*l.* of capital was about 160*l.* worth of goods. By 1893 the output had risen to 188*l.* In 1906 it was 200*l.*, in 1916 it was 230*l.*, and in 1918 260*l.* for each 100*l.* of capital. For 1919 there was a further increase. Mr. Greening then gave the following latest figures: Number of societies, 95; of employees, 10,136; capital employed, 2,299,615*l.*; business of the year, 7,047,147*l.*; profit or surplus, 486,752*l.* He added that the percentage of profit over the whole of these businesses now worked out to over 21 per cent. The output or sales on each 100*l.* of capital was over 300*l.*, or nearly double the output of 1883. These results, obtained with shorter hours and better conditions for the workers, had no doubt been due to the introduction of new machinery and improved organisation of work. But the readiness of the workers to vote for more machinery and better organisation must be credited to the influence of profit-sharing co-partnership.

After proposing the health of Mr. Greening, Lord Burnham said he did not want co-partnership to assume any stereotyped system; co-partnership might be adapted in many ways to the necessity and to the progressive advancement of various industries. It seemed to him that there could be no true method of co-operation unless the work-people were enabled to have a real and permanent interest in the organisation of which they were a part. What they wanted to do was altogether to get rid of the atmosphere of suspicion and ill-will on all sides.

THE BIRMINGHAM EXCHANGE.—The directory for 1921 of members, subscribers and representatives to the Birmingham Exchange, issued by the Committee, is now available, at the price of 2*s.* 6*d.*

REINFORCED CONCRETE FOR WHARVES AND BREAKWATERS: ERRATUM.—In our report of Section II of the recent Engineering Conference of the Institution of Civil Engineers, we gave, on page 40 *ante*, column 2 line 20, the statement that some of the cribs used at Montreal were "about 60 ft. in length"; this is a mistake, Mr. FitzGibbon having said that the cribs were about 160 ft. in length.

THE STEADY MOTION OF AN AEROPLANE.—In Report No. 97, recently issued by the United States National Advisory Committee for Aeronautics, the author, Mr. G. de Bothezat, explains the history of a method for studying the steady motion of an aeroplane, which differs from other methods in use. M. Paul Painlevé, the author mentions, pointed out in 1910 that the drag-lift curve formed a convenient means of studying aeroplane motion, and the author has previously added to the drag-lift curve, a "speed curve," which permits a direct checking of the speed of the aeroplane under all flying conditions. The speed curve, however, was plotted in the same quadrant as the drag-lift curve. Later, the author was brought to add three other quadrants to the original quadrant, and thus was obtained the steady-motion chart which is described in detail in the report. This chart, therefore, permits one to read directly for a given aeroplane its horizontal speed at any altitude, its rate of climb at any altitude, its apparent inclination to the horizon at any moment, its ceiling, its propeller thrust, revolutions, efficiency and power absorbed, *i.e.*, the complete set of quantities involved in the subject, and to follow the variations of all quantities both for variable altitude and for variable throttle. The chart also permits one to follow the variation of all of the above quantities in flight as a function of the lift coefficient and of the speed. The author also discusses the interaction of the aeroplane and propeller through the slip-stream, and the question of the properties of the engine-propeller system and its dependence upon the properties of the engine considered alone and of the propeller considered alone. There is also a discussion of the question of a standard atmosphere. The general theory of the steady motion of an airplane is also developed, and after the basic equations have been established, and the methods to be used described, a general survey of the properties of aeroplane steady motion is given. A detailed discussion of climbing phenomena will be found and the general formulæ established for the rate of climb and time of climb, which quantities, under the simplest assumptions, appear as hyperbolic functions of the ceiling. A copy of the report may be obtained upon request from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Despite the few substantial contracts placed by foreign powers, armament departments are insecurely situated as regards the future, and it is becoming a question as to whether, despite the Government subsidy, it is in the interests of the big engineering firms to maintain expensive plant in running order against future requirements. Makers of shipbuilding materials anticipate that a considerable measure of benefit will accrue from the wages reduction in the engineering trades. In no case is the reduction sufficient to enable them to guarantee that they can obtain orders, but it does place them in the position of being able to quote more economically, and thus to stand a better chance of meeting foreign competition. Now that Sheffield Corporation's proposal to purchase German electrical plant has been withdrawn for further consideration, it is expected that the contract will be placed with a British manufacturing concern, and that the forgings and discs for this generating plant will be made in Sheffield. Progress at the moment is chiefly in textile machinery and machine tools. The British Petroleum Company, Limited, have placed in Sheffield an order for 45 tank wagons of 14 tons capacity each. In the heavy steel section orders are badly needed. A few open-hearth furnaces have restarted, and some of the Bessemer and Siemens departments are turning out a minor tonnage, but this chiefly represents arrears of orders that accumulated before the coal stoppage. The downward trend of prices of raw and semi-finished materials continues. Steel billets and wire rods have been marked down by 2*l.* to 3*l.* a ton. Bright drawn steel is down by as much as 5*l.* per ton, and crown bars by as much as 5*l.* to 6*l.* per ton. Owing to keen competition for new business, quotations show great variation, and are unreliable.

South Yorkshire Coal Trade.—The urgent need of cheaper fuel in iron and steel production is probably in part responsible for the prophecy coming from leading engineering masters that a marked reduction in the price of manufacturing brands may be looked for in the autumn. At the moment there is no solid indicaton in this direction. The disparity between quotations tends to widen. While some of the leading pits in South Yorkshire are adhering to the decision arrived at at Derby to charge uniform advances and others are demanding advances at the pithead considerably in excess of these figures, an increasing number of colliery owners decline to sanction any increase on the pre-strike quotations. After the initial rush for house fuel following the strike settlement, business is tapering off, but merchants have booked more orders than they can comfortably handle for two months. Preferential treatment in the matter of deliveries is being shown to the railway and public utility services. Until conditions become more stabilised quotations are not reliable.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues quiet. No. 1 is no longer to be had, and stock of No. 3 is dwindling. So scarce has the latter quality become that it is now practically impossible to place an order for it unless an equal quantity of No. 4 foundry is purchased at the same time. The commoner kinds are quite abundant, and producers are very keen to reduce their heavy stocks by selling at the agreed-on minima, but customers are difficult to find. For home consumption, No. 3 and No. 4 foundry are 135*s.* for prompt delivery, and the export price is 140*s.* for prompt shipment. For next month's delivery 5*s.* above the foregoing rates rule. No. 4 forge and mottled are being pressed on the market at 117*s.* 6*d.* and white is offered freely at 115*s.*

Hematite.—Makers offer to sell Nos. 1, 2 and 3 East Coast hematite at 140*s.*, and even a trifle less, for export, fails to attract buyers. The home quotation of mixed Nos. stands at 160*s.*

Foreign Ore.—With consumers carrying large stocks and substantial lots still to be delivered against contracts made, new business in foreign ore threatens to be held up for some time.

Coke.—Coke is something weaker, but prices are still far too high. Sellers are now offering blast-furnace quality at 45*s.* delivered, which is quite 10*s.* above what local consumers are prepared to pay.

Manufactured Iron and Steel.—There is not much new ascertainable concerning finished iron and steel. Output at the works is increasing as coal supplies improve. New orders are scarce, but many firms have substantial portions of old contracts to complete. Among the principal market quotations are :—Common iron bars 16*l.* ; marked bars, 20*l.* ; steel billets, 12*l.* 10*s.* to 13*l.* ; steel boiler plates, 21*l.* ; steel ship, bridge and tank plates, 15*l.* ; steel angles and joists, 14*l.* 10*s.* ; heavy sections of steel rails, 14*l.* ; fishplates, 19*l.* ; sleepers, 19*l.*, black sheets, 19*l.* ; and corrugated galvanised sheets, 23*l.* 10*s.*

Ironstone Miners' Wages.—The question of the Cleveland ironstone miners' wages, which had been deferred until after the settlement was reached in the coal industry, was again reviewed at a meeting of the mine owners and miners' representatives at Middlesbrough this week. The subject was discussed at considerable length, and finally the owners offered terms representing a reduction, for the purpose of setting away the mines. They promised that if these terms were accepted the mines would be worked to their fullest extent possible. It has been decided that the terms be submitted to the men, and a further meeting of owners and miners' representatives will be held, if necessary on the 2nd proximo.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The past week has witnessed little change in the general state of trade throughout the country. So many places are closely connected with Glasgow that owing to the annual holidays there the closing up of all works in the city affects all the surrounding area. When the various establishments resume operations next week it will only be on a limited scale because of the shortage of fuel. The latter is also very dear yet, and of course the opening out of business cannot be expected until cheaper prices prevail.

Scottish Steel and Iron Trades.—One or two of the works in the West of Scotland which made a partial opening with the close of the miners' strike are carrying on in some of the departments this week. There is very little doing, however, and it will be some weeks before conditions become anything like normal. There are prospects of fuel becoming easier in price in the near future, and the moment that takes place business will begin to open out. Supplies of material have been coming in from the Continent with regularity, and there is thus a goodly quantity of low-priced stuff in the market for disposal, which means that there will be a smaller demand for local makes during the next few weeks. Bookings have not been heavy, and even when the various works open up after the holidays there is little to make a commencement with. Inquiries are of no large volume either from home consumers or from abroad. Prices are unchanged.

Scottish Pig-Iron Trade.—The Scottish pig-iron market is dull and quiet, and few establishments have much stock left over for disposal. This is particularly so in the case of foundry qualities, and stocks of this class of iron are likely to be cleared out before manufacturing again takes place. Furnaces have not yet been put into blast owing to the dearness of coal, but there are fair lots of hematite still available. Prices show no alteration meantime.

UTILISATION OF EXHAUST STEAM: ERRATUM.—We regret that in reporting the discussion of the paper by Mr. E. R. Dolby, on "The Utilisation of Exhaust Steam," at the Engineering Conference of the Institution of Civil Engineers (page 43 of our issue of July 8), there were two inaccuracies in the names of speakers. "Mr. Haydon" should have been "Mr. Haden' and "Mr. Payne" should have been "Mr. Pain."

STRAW FILTERS AND SEWAGE PURIFICATION: ERRATUM.—In the report of the discussion on this subject at the Engineering Conference of the Institution of Civil Engineers, given on page 115 of last week's issue, we printed Lord Elveden's name as Lord Eldon in Mr. E. H. Richard's remarks. This we regret in view of the support given by Lord Elveden, perhaps better known under his former name as the Hon. Rupert Guinness, in connection with agricultural science.

"PENROL" MOTOR FUEL.—We read in *The South African Engineer and Electrical Review* that the Union of South Africa may become self-supporting in the matter of motor fuel, by the use of "Penrol," a new spirit discovered by Mr. J. Penhale, Johannesburg, which is fundamentally a combination of alcohol and dissolved acetylene. It has been subjected to most exhaustive tests by motor users in various parts of South Africa, many thousands of miles have been run with it, and the general consensus of opinion is that "Penrol" not only compares with petrol, but that it has important advantages in other directions.

MARINE MOTOR SHOW.—As provisionally decided some months ago, the Marine Motor Show will be held at White City in November, in connection with the Motor Exhibition. It will be recalled that when the Society of Motor Manufacturers and Traders, on the recommendation of its Marine Section Committee, abandoned the Motor Boat Exhibition which was proposed for March last, the decision was reached that a marine section should be organised in connection with the November fixture. From every point of view autumn was regarded as the best time of the year for such an event. The buildings in which the Marine Motor Show will be installed are directly connected with the motor exhibition, and provide the requisite facilities for handling and organisation.

RESEARCH.—The Research Association of British Motor and Allied Manufacturers, of 15, Bolton-road, Chiswick, W. 4, has entered on its second year of activity and is now in a position to extend its experimental work. A new laboratory recently built is now practically equipped and a staff of scientific workers has been engaged. At the annual general meeting, held in June, Mr. H. C. B. Underdown, chairman and managing director of Commercial Cars, Limited, was elected president and the following gentlemen were elected vice-presidents: Sir Dugald Clerk, K.B.E., F.R.S., D.Sc. ; Lieutenant Colonel J. A. Cole, O.B.E., managing director of Messrs. Humber, Limited, and D. F. W. Lanchester, M.Inst.C.E. It is to be regretted that this association does not receive from the industry the full support it deserves, so that while its development is still possible, an unfair burden is placed on the few who inaugurated the movement.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—An important step in the direction of the restoration of pre-war conditions in the South Wales coalfield was made yesterday when at a joint meeting of owners and miners' representatives it was agreed to establish immediately a new District Board. To all intents and purposes this Board will be the same as the old Conciliation Board, and will be the administrative authority in the South Wales coalfield as regards the fixing of the conditions of employment. It was, however, decided that a Disputes Committee should at once be formed to deal with various difficulties which have arisen at some of the collieries in connection with the application of the national terms of settlement for the resumption of work. This committee, again, simply means the revival of the old Disputes Committee, which during its existence did a vast amount of good work in dealing promptly with grievances and preventing an extension of troubles. It was also decided to draft a new agreement in conformity with the terms of the national settlement. Suggestions have been made that the owners and workmen were at variance as to the precise effect of the national settlement, but it was found yesterday that there was no divergence of views on the subject as far as the owners and miners' leaders are concerned. This fact of itself clears the air, and there is every likelihood of a much better feeling prevailing in the future than has been the case in the past, and that the owners and workmen will be in a position to co-operate more effectively in the interests of the industry than has hitherto been the case. In the meantime, though outputs have rapidly improved, inland commitments have been so heavy since the resumption of work that collieries have had little available for export. Indeed it is reported that in a number of instances collieries have got back to pre-strike outputs, while in some cases they are back to 1913 levels, and this with less men than those employed before the strike. These facts are significant, as it displays an earnest desire on the part of the men to do what they can to bring back to South Wales the business lost by under-production. At the moment coal prices are maintained on the basis of 47*s.* 6*d.* for best large, 35*s.* for throughs and from 22*s.* 6*d.* to 27*s.* 6*d.* for smalls, but it is confidently expected that there will soon be a substantial fall in prices, for it is anticipated that most of the collieries, now idle through disputes and accidents, will be at work after the holidays. The American coal thrown on the market for sale by the Government during the past week has not had any appreciable effect for, as far as South Wales is concerned, not one sale was reported, though the coal was offered at 40*s.* to 45*s.* per ton c.i.f., or about 32*s.* per ton less than what it cost the Government. The new Ellerman steamer, City of Dunedin has arrived at Cardiff to load 11,000 tons of "crown" patent fuel for shipment to Karachi, on Indian Government account. This is the largest single cargo ever shipped from the Bristol Channel. The patent fuel manufacturers have made an application for a 20 per cent. reduction in the workers' wages, and it is expected that a decision on the matter will be reached next week.

The Iron and Steel Trades.—Though there is not much change in general conditions, it is satisfactory to record that the Welsh tin-plate mills are gradually restarting, and it is estimated that about 15 per cent. are now in operation. A settled price for coal is required before any appreciable improvement can be expected.

THE INSTITUTION OF ELECTRICAL ENGINEERS: A.M.I.E.E. EXAMINATION.—It is proposed, if a sufficient number of candidates make application to hold an examination for associate membership in London and at other places (at home and abroad) in October, 1921. An entry form and full particulars may be obtained on application to the Secretary of the Institution, Savoy-place, Victoria Embankment, London, W.C. 2.

DISPOSAL OF GOVERNMENT AIRSHIPS.—In response to the Government's offer to hand over the airships in their possession to a private concern undertaking to operate them commercially, the terms of which offer were referred to on page 688 of our last volume, we understand that only three of the schemes put forward have been found to merit consideration. One of these was by Mr. A. H. Ashbolt, the Agent-General for Tasmania, and another by Mr. M. M. Greenhill, and both these schemes, which contemplated developing routes to Egypt, India, South Africa and Australia, included the payment by the Dominions of a small subsidy when regular services were established. The third scheme, submitted by Lieutenant Commander Ballantyne, covered the operation of the airships between England, Italy, Egypt and South Africa, and did not include a subsidy from the Dominions, but all three schemes submit a public share issue. The opportunity has been taken to lay before the Special Conference of Dominion Prime Ministers the full facts regarding the position of airships with special reference to their utilisation for speeding-up communications with the Dominions. The conference, after having considered the question, especially the above-mentioned proposals, has appointed a technical and expert committee under the chairmanship of the Secretary of State for Air, to report on the cost of inaugurating and maintaining an airship service with special reference to the routes between England, India, Africa, Australia and New Zealand. The committee, which met first on Tuesday last, will also consider aeroplane services and will present their report before the Imperial Conference terminates.

MECHANICAL MANIPULATORS FOR HEAVY FORGINGS.

CONSTRUCTED BY THE ALLIANCE MACHINE COMPANY, ENGINEERS, ALLIANCE, OHIO, U.S.A.

(*For Description, see Page* 151.)

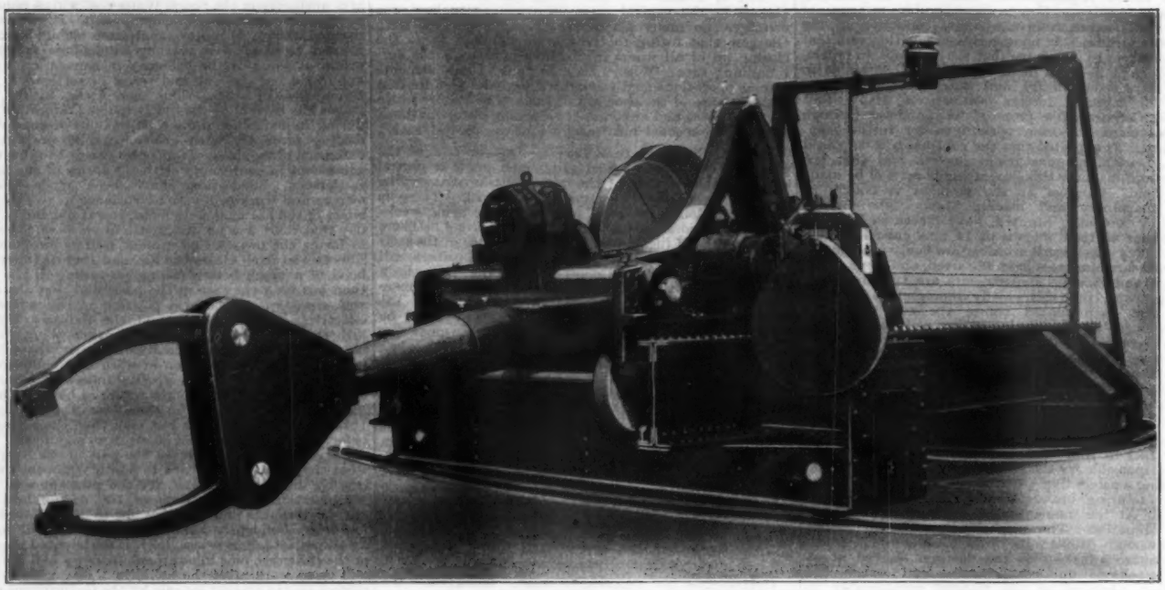


FIG. 2. TWO-TON MANIPULATOR, LOW GROUND TYPE.

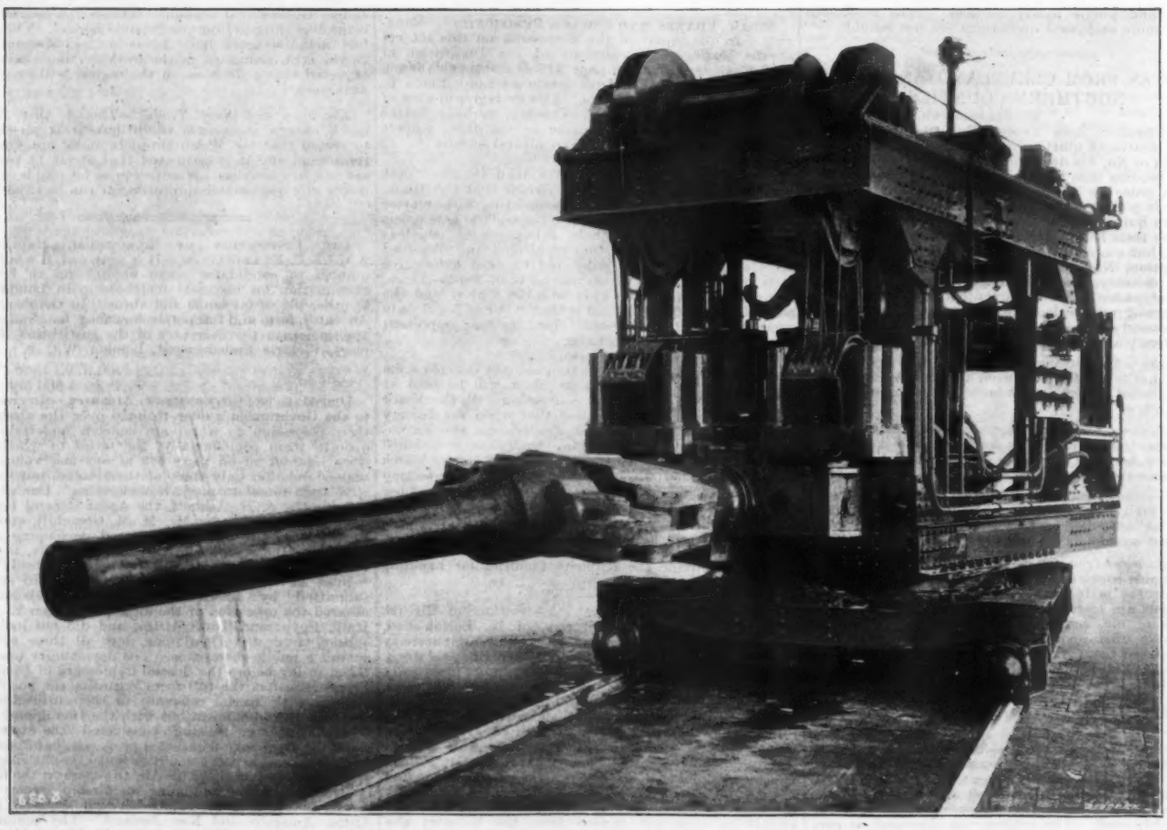


FIG. 3. FIVE-TON MANIPULATOR, UNIVERSAL GROUND TYPE.

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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD

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With a Two-Page Plate of the SULPHATE OF AMMONIA PLANT AT LEAMINGTON GAS WORKS.

ENGINEERING.

FRIDAY, JULY 22, 1921.

THE ENGINEERING CONFERENCES.

AT no time in history we imagine was it found satisfactory to attempt the determination of complicated affairs by large committees or conferences. Such bodies, if they are to do useful work of this kind must be led by a few men, and it is probable that out ancestors' Witenagemote was equally controlled in this way as our present Parliament. A large body has, however, a very useful sphere to serve, particularly if it is made up of selected members. Such a body brings together many individual points of view and gives opportunity for the interchange of information and opinion, and if the conference which such a body constitutes has no definite and formal aim, and is faced by no necessity for coming to definite conclusions, it is all to the good. Freedom from the control which is necessary when definite business has to be transacted is likely to lead to a more individual atmosphere and to the freer statement of personal opinion.

That the value of such conferences is generally recognised is sufficiently made evident by the meetings of this kind dealing with most subjects of human interest which are held in London, or elsewhere, every year, and although in the engineering sphere some of the purposes of such conferences are served by the technical meetings and discussions which are such a valuable feature of the practice of the profession, there is much to be said for an occasional all-embracing conference such as that held at the end of last month by the Institution of Civil Engineers. Such a conference is particularly valuable in the opportunity it affords for members representing different branches of engineering work to come together and discuss questions of mutual interest.

The membership of the Institution of Civil Engineers embraces representatives of practically every aspect of engineering, so that without going outside the sphere of work for which it stands the Institution is able to concern itself with practically any engineering problem. Owing to the exigencies of time and space the ordinary proceedings of the Institution are, however, largely concerned with works of the character which has commonly come to be known as "civil," and very many branches of engineering are hardly touched on by the ordinary meetings. This is unavoidable, and apart from anything else conferences of this kind are of value to many members in bringing their own special line of work into discussion before the Institution. It was particularly, however, in bringing about joint discussions between engineers representing different branches of work that the conference was of value.

It is, for example, very much to the good that mechanical and electrical engineers should have been brought together to hear and discuss Sir Vincent Raven's paper on electric locomotives. The problem of the development of such locomotives suited for general service in this country is of great interest and importance. It is also equally mechanical and electrical. In the specialised engineering institutions there is of necessity a somewhat specialised point of view, and it is natural and inevitable that when electric locomotives are discussed before the Institution of Electrical Engineers the electrical side of the problem should be accentuated to the partial neglect of the mechanical. A discussion before the Institution of Locomotive Engineers or the Institution of Mechanical Engineers would probably, on the other hand, tend to concern itself too purely with the mechanical side.

Another excellent example of a valuable joint discussion was furnished by the meetings in which the papers on docks and ship dimensions and unloading equipment were dealt with. These problems concern almost equally the naval architect, the civil engineer and the mechanical engineer, while the electrical engineer has an important watching brief. It was not only, however, in the formal joint discussions that lines of work of interest and importance to individual engineers, and yet lying somewhat outside their ordinary experience, were brought forward. Many engineers attending the conference would doubtless have their attention directed to subjects dealt with in other sections than that which they considered formally their own, and many certainly attended discussions bearing indirectly but in an important way on their work. The interest that was aroused and the information which was imparted in this way would be reinforced by the personal conversations and introductions which in very large numbers are a necessary feature of a conference of this kind.

The type of joint meeting to which we have referred need not, of course, be confined to special conferences, and several of our engineering and scientific institutions have in recent years made a start with such meetings as a feature of their ordinary sessions. One may expect to see further development of this movement, which is not merely valuable, but, with the development of engineering and physical science, is becoming a necessity. In its earliest phases engineering covered such a comparatively small field that it could be grasped in its entirety by one man. As it developed, independent branches came into existence which were dealt with by special practitioners whose activities workers in other branches could largely afford to ignore. Modern development is, however, bringing us nearer to the original unity of engineering practice and theory. It is, of course, not possible for any one to become familiar with the details of every branch of work, but their interdependence is becoming every day more obvious and with it the value of a general working knowledge of as large a portion of the field as possible.

A growing realisation of the unity of all engineering may have something to do with the current idea that some form of federation of engineering institutions is desirable. Such federation would not give an electrical engineer the qualifications of a naval architect, but it would bring electrical engineers and naval architects closer together and would enable each better to appreciate the problems and difficulties of the other. The idea of such federation was specifically raised at the conference, and in the course of the next year or two its advantages and disadvantages will no doubt be discussed in general terms. In the meantime some of the advantages of such federation may be obtained by a continuance of the policy of joint meetings.

The conference held by the Institution of Civil Engineers was not a joint meeting in the sense to which we have just been referring, but as it covered so much ground and was attended by many engineers not members of the Institution, it served all the purposes of such a conference and incidentally illustrated the interdependence of all branches of engineering in the number of sectional papers read, which obviously must have attracted members of other sections. The conference being the fifth of its kind was not a novelty, but it had a special interest and importance owing to the long interval which has necessarily elapsed since its predecessor and owing to the growing feeling of the interdependence of all branches of engineering to which we have referred. The proceedings of the conference generally rose to a high standard, and we felt no hesitation in devoting very considerable space to their record. The reports of many of the discussions form a valuable record of the present state of engineering opinion on some feature of practice, and will be of great value in fixing ideas and one may hope in assisting progress.

So far we have said nothing of the conference held by the Institution of Mechanical Engineers. This formed a valuable complement to the Civil Engineers Conference, and, being held at the same time, certainly enabled many engineers to spend a very profitable time at Westminster. It formed an admirable example of an alternative form of conference, and, by bringing forward many of the detail features of a single subject, enabled a fuller overall discussion to take place than was possible in the more varied meetings held by the Institution of Civil Engineers. Such a specialised conference could, of course, if desired, embrace the advantages of joint meetings with other institutions, and a

combined summer meeting of several institutions devoted to the examination of the various aspects of some important engineering problem would appear to be a valuable possibility of the future.

As the last portion of our reports of the conferences appears in this issue the present week concludes what has been for us a somewhat heavy task, but one that we feel will have been of very considerable interest and value to our readers. In here concluding the whole matter we must pay our tribute to the admirable way in which both conferences were organised and to the able services rendered by Mr. Brodie, the President of the Institution of Civil Engineers, and to Captain Sankey, the President of the Institution of Mechanical Engineers, as well as the various sectional chairmen and honorary secretaries whose names will be familiar to most of our readers, but which considerations of space prevent us from repeating here.

CANAL PROPOSALS.

SOME three months ago a committee appointed by the Ministry of Transport issued a report discussing the principle of the railway companies of this country embarking upon road transport, and our comments on the matter were recorded in our issue of April 15 (page 460). Since that date a good deal has been heard from the road transport interests, due mainly to the introduction of the Railways Bill, and the discussion of its clauses in and out of Parliament. The coastwise shipping interest is also making itself heard in a similar strain, and now we have a report on inland waterways couched much in the same terms.

The general idea, as far as we understood it, behind the Ministry of Transport, when it was introduced, was the co-ordination of the transport facilities of this country. Instead, it seems to have afforded the opportunity for a general attack upon the railways by other parties posing as philanthropic concerns run mainly with a view to benefitting the country. The report of the Committee on Road Conveyance of Goods by Railways adroitly remarked that every trader would secure a monopoly if he could. The curious thing is that the people who cry so loudly for restrictions to be imposed on the railways cannot see that they are asking for just what they consider should be denied to their rivals.

The Committee on Inland Waterways along with the others, takes up the attitude that if canals were resuscitated the railways would immediately make a dead set against them and strangle them. That is not stated quite so baldly in the report, but is about what the argument amounts to. It may be pointed out that the Railways Bill dealt very fully, in the form in which it was introduced, with standard and exceptional rates, and though modifications are likely in the final form, it appears certain that the latter will still be under considerable control if the Bill becomes law. It is the exceptional rate question which is the concern of the road transport, the shipping interests, and now of the canals. The Committee on Canals proposes that special concessions offered by the railways should be barred by statute. The motor transport people would like the same and so would the coastwise shipping trade. The Rates Advisory Committee, on whose report, published last year, the rate clauses of the present Bill are based, was quite definite on this point. It considered that competition by the railway companies to secure traffic which showed a profit was legitimate, but that aimed at destroying the competitor should be condemned. The result has been the clauses giving the Rates Tribunal power to review exceptional rates. With this safeguard it would appear that the opposing interests are endeavouring to raise a rather unnecessary scare, as the railways' influence will not be predominant on the tribunal.

The Canal Committee we are glad to note has not indulged in any elaborate schemes. It notes in passing that nationalisation of the inland waterways is outside practical politics at the moment, and that funds are lacking for large schemes of any kind. Its idea is that a beginning of a more or less tentative nature should be made with a suitable group of canals, which group it claims to have found in the Trent and eastern counties district It is proposed that the general lines of policy of the country should take the direction of the formation of public trusts which would acquire groups of canals, the country for this purpose being divided among some seven groups. These trusts would acquire the canals, and each group would be worked under a single ownership, the trust both having the power to act as carrier and also as toll authorities. It is proposed that the public or local authorities should assist in the development, and that the trust should have power to acquire frontages, &c., with a view to benefitting by improved values, and so on.

It is interesting to note that at the very moment when the Committee announces that it would be necessary for a canal trust to be a common carrier as well as a toll collecting body, the Leeds and Liverpool Canal Company, the Shropshire Union Canal, and the Rochdale Canal have all decided to cease to act as common carriers as the business is not remunerative, and to confine their operations to working their canals and taking tolls for their use by large owners.

The most satisfactory point about the whole proposal is, in these days of reckless spending, the comparatively modest scale on which the committee place the preliminary experimental scheme. The group chosen is one which they state only needs half a million to make it possible for 120-ton barges to go up to Nottingham. But, as Sir W. Acworth points out in a supplementary report, that expenditure is based on pre-war estimates, while he also doubts the effectiveness of carriage in 120-ton barges, in view of the fact that well placed waterways on the Continent and America are finding it difficult to pay their way though operating with barges of 1,000 tons capacity. The whole subject is one which wants treating with great circumspection. There are doubtless many property owners who would like to see canal transport resuscitated on a large scale, and of course traders favourably situated, but it is not our opinion that this system of transport will ever be economically revived in this country of short distances. Now that road transport has come, with its door-to-door service and the railways can handle the heavy traffic adequately, there seems to be little object in embarking upon elaborate programmes in connection with a form of conveyance which after all offers comparatively few facilities, and is only suited for a very limited type of traffic.

WAR PATENTS.

THE date has just passed by which patent applications held in abeyance or lapsed during the war period had to be accepted under the continuation of the temporary rules. It is known that a large number of these applications were held up—either through the fault of the applicant or unavoidably owing to pressure of work in the Patent Office—for some little time, with the result that many have just been accepted. This means that in the near future in all probability there will be a large number of patent specifications published bearing application dates possibly some years old. It is therefore necessary for patentees and for manufacturers closely to watch the accepted specifications in case their rights are being assailed or in the event of these patents preventing manufacture of articles it is desired to make. It may be possible to oppose the grant of some of these patents, but the grounds of opposition are very limited. Even for some months the field will not be clear because under the Peace Treaty it was possible for foreign applications to be filed in this country on or before January 10 last claiming dates to the early part of the war. These specifications may not be accepted until the beginning, or even the middle, of next year in certain circumstances, and it may happen that manufacturers in this country will inadvertently be employing what they claim, not knowing of the existence of the patents.

In this connection attention should be called to the provisions of the Peace Treaty and to what is known as the Berne Convention. From the point of view of manufacture the important article of the Peace Treaty is No. 309, which provides that no action shall be brought and no claim made by persons residing or carrying on business within the territories of Germany or of the allied powers by reason of any action which has taken place within the territory of the other party between the date of the declaration of war and that of the coming into force of this treaty, which might constitute an infringement of the rights of industrial property either existing at any time during the war or revived under this treaty. Further, no action for infringement by such persons shall at any time be permissible in the respect of the sale for a period of one year after the signature of the treaty of articles manufactured during the period between the declaration of war and the signature of the treaty or against those who have acquired and continued to use them.

According to the Berne Convention of September 30, 1920, an extension of the terms provided for by what is known as the International Convention, was agreed to, but it was provided that this extension should not prejudice the rights of any party possessed at the coming into force of the agreement of *bona fide* rights which might conflict with those applied for under the agreement when claiming the period of priority. It is said that these individuals are to retain possession of their rights without any liability to be disturbed or prosecuted as counterfeiters. This is of great importance to manufacturers and it is necessary to scrutinise all patents granted under the extended terms referred to above very carefully if one has been manufacturing on the lines of these patents to make sure that one is able to continue, either through limitation of claims or restriction of the terms of grant in view of the above.

ENGINEERING PRODUCTION.

So very much has been said of late about the necessity for increased production of all kinds in this country that at first sight it might well be imagined that there is nothing more to be said. We think this idea not correct, however. Although very much has been said, most of it has been said by people who could not produce a five-eighth washer, and the really useful contributions to the discussion, which explain how the desired greater production is to be obtained, have been none too plentiful. We were glad to hear a speaker at the meeting of the new Institution of Production Engineers last Friday say that the Institution must concern itself with definite production methods and means if it were to be successful and that a mere iteration of pious generalities would lead nowhere. These words are our own, but we think they properly represent the speaker's point of view.

The occasion of these remarks was the reading of a paper on "Production and the Engineer" before the Institution, by Mr. Max. R. Lawrence. As this was the first ordinary meeting of the new Institution Mr. Lawrence's address was largely of an introductory character, and the remarks we have referred to were not intended as a criticism of it. It was naturally very desirable that the first meeting should concern itself with a general survey of the field to be covered by the activities of the Institution and with an attempt to define the status and duties of a production engineer. Mr. Lawrence dealt with this latter consideration in some detail, and the discussion following his paper largely concerned itself with the same matter.

We do not at the moment propose to follow Mr. Lawrence in an attempt to define a production engineer, but rather to enlarge a little upon a matter which was incidentally referred to in his paper, but did not claim the attention of the meeting. In doing this we are indulging in the generalities about which we have made unkind remarks earlier, but the aspect of the subject to which we wish to refer has certainly received far too little attention. Referring to the development of production methods and the increase in outputs which they lead to, Mr. Lawrence said "Many men who are more or less captains in industry, or, anyway, directors of engineering concerns, I am afraid do not always realise, and recognise, the men whose judgment they rely upon to steer them successfully from shallow into deep waters." This quotation introduces a vital aspect of the whole production question as it affects this country.

We hesitate to estimate the percentage of the production talk which has concerned itself with the duties of the working man, but have no hesitation at all in saying that he has had very much more than his share of the total. We know all about trade union restrictions and the very serious effect they have had, and are having, on the trade of the country, and have no wish to minimise the labour difficulties with which many manufacturers have to contend. Admitting all these things, it is very necessary that full recognition should be given to the fact that production is by no means merely a question of harder work and greater application by the operative. It is also and very vitally a question for the employer. There are many brilliant exceptions in this country, but in very many cases it is quite fair to say, that the ignorance of the employer has been as great an obstacle to progress in production as the reluctance of the workman.

Production in the modern sense cannot be obtained by merely buying a lot of capstan lathes and fixing them down in a row—nor even by staggering them. The whole complicated process of what is being aimed at, and at least the broad details of the methods proposed, must be clear in someone's mind, and very preferably in the mind of the employer. A speaker in the discussion on Mr. Lawrence's paper, referring to quality of workmanship, said the products of any firm were a reflex of the mentality of the board of directors of the firm. This is singularly true, but in these days of great corporations is perhaps apt to be overlooked. No adequate production in the special meaning which the term has come to have can be obtained by a firm of which the directors do not understand that special meaning. It may be said the directors can put themselves in the hands of their manager, but in the limit this is not true. The directors are the shareholders' representatives and carry ultimate responsibility, and sooner or later they must interfere for good or ill. If they do not understand the meaning of modern production the chances are they will interfere for ill.

The fact that there are so many boards of directors with the negative qualifications we have referred to adds a special interest to the inauguration of the Institution of Production Engineers and places an important possibility in its way. If the Institution is managed in an able way and its proceedings reach a high standard it may do much to spread a general realisation of the fact that production cannot be obtained merely by talking about it or even by raising large blocks of fresh capital. It may even do something to improve the whole status of the men by whom production is really obtained and possibly give them a greater control in industry. It is, however, particularly in the direction of educating the employer that one hopes the Institution may assist. It is in no way necessary that the chairman of a large manufacturing company should be a judge of the best way of machining a connecting rod, but it is in every way necessary that he should have clear ideas about the features of management and shop procedure which are necessary for the machining of the rod in the cheapest way.

We hardly imagine that managing directors are likely to join the Institution of Production Engineers on any very wholesale scale, but if the body sets a high standard and becomes important, it may do much to increase general interest in the details of production and to establish the important position which the production engineer should occupy. This last phrase raises a question to which we may refer in closing. Many will no doubt ask what a production engineer is and in what he differs from a works manager or a shop superintendent. This question is difficult to answer, and in many senses has no answer. We need not enter into it now as we think we are correct in saying that the new Institution proposes to embrace all people interested in production, and has no intention of confining its membership or proceedings within any narrow definition of production engineering. A further point which arises is that much of the work it may do really lies within the sphere of the Institution of Mechanical Engineers and other bodies. There is much in this, but up to the present the field has not been touched by such institutions except in the most desultory and occasional way, so that one has no difficulty in understanding this inauguration of a further specialised institution.

MERCHANT SHIPPING OF THE WORLD.

IN dealing with the effect of the war on the world's merchant shipping, in an article which appeared about a year ago (on page 152 of our 110th volume) we compared the position of the merchant fleets of the more important maritime countries at that time with their positions in 1914, and showed that collectively the world's shipping was some 3,500,000 tons less than it probably would have been had the war not intervened. While some countries, notably the United States, had materially augmented their merchant fleets during the war period, the gross tonnage of steamers and motor vessels actually possessed by the United Kingdom was estimated to be about 3,309,000 tons lower than if it had developed normally in a period of peace.

The tonnage of the British merchant fleet at that time, neglecting sailing vessels, was 18,111,000, in round figures, instead of 21,420,000 tons, and to-day, according to the statistics included in Lloyd's Register Book, just issued, the corresponding figure is only 19,320,000 tons. The additions during the year thus amount to 1,209,000 tons, or 6·7 per cent., and leave us still 2,100,000 tons short of the position we should have occupied a year ago. Neglecting a few self-propelled vessels of wood and composite construction, as well as the sailing vessels, the tonnage of the British merchant fleet is now 19,288,000, to the nearest 1,000 tons, and this figure is only 411,000 tons greater than the corresponding one of 18,877,000 tons for June, 1914. The British steel and iron sea-going tonnage has thus increased by only a little more than 2 per cent. in seven years. The British Dominions have, however, improved their maritime position by 38 per cent. in the same period, the tonnage owned by the Dominions collectively having increased by 543,000 tons from 1,407,000 tons in 1914, to 1,950,000 tons at the present time.

Still considering only self-propelled sea-going tonnage of steel and iron construction it will be interesting to compare the changes that have occurred in the same septennial period in the merchant fleets of other countries with that mentioned above for the United Kingdom. The United States now owns 12,314,000 gross tons of the class of shipping we are referring to, as compared with 1,837,000 gross tons in June, 1914, so that the American merchant navy is now of nearly seven times its pre-war magnitude and contains almost 23 per cent. of the world's total tonnage. The British tonnage, it may be mentioned, accounts for 35·6 per cent. of the world's total now, as compared with 44·5 per cent. in 1914, at which time the United States tonnage was only a little more than 4 per cent. of the world's total.

Japan, which owns the third largest merchant fleet of steel or iron sea-going self-propelled vessels, is closely followed by France, and both these countries have considerably augmented their tonnages since 1914. At that time Japan owned 1,642,000 gross tons of steel or iron steamers, whereas the figure is now 3,063,000 tons, an increase of 86½ per cent. The increase in the case of France is from 1,918,000 gross tons in 1914 to 3,046,000 tons at the present time, the difference representing 59 per cent. of the 1914 tonnage. The Italian tonnage has been increased by over 66 per cent., from 1,428,000 tons to 2,378,000 tons, during the last seven years, so that Italy now takes fifth place among the shipowning nations of the world. As is also the case with the United Kingdom and France, the Italian merchant fleet now includes a considerable amount of ex-enemy tonnage allotted to that country.

Among the Scandinavian nations the greatest development has occurred in the fleet of Norway, although the increase in that country is not quite 19 per cent. Norway now owns 2,285,000 tons of steel and iron sea-going ships, as compared with 1,923,000 in 1914. The figures for Sweden are 992,000 tons in 1914 and 1,037,000 tons at the present time, showing an increase of only 4½ per cent., while those for Denmark show an increase of nearly 13 per cent.; the actual figures for the latter country are 768,000 tons in 1914 and 866,000 tons at present. Both Holland and Spain show notable increases in tonnage, Dutch shipping having been augmented by almost exactly 50 per cent. in the period under consideration, while the Spanish merchant fleet has grown to the extent of 24 per cent. The tonnage of vessels of the class we have been referring to now owned in Holland amounts to 2,207,000, as compared with 1,471,000 in 1914, and the corresponding figures for Spain are 1,094,000 at the present time and 883,000 in 1914.

Apart from ex-enemy countries, the only nation of which the merchant fleet is smaller than in pre-war times is Greece, that country now owning 244,000 tons less shipping than it did in 1914. The Greek merchant tonnage now stands at 576,000 as against 820,000 immediately before the war, the difference amounting to about 30 per cent. of the latter figure. Of ex-enemy countries, Austria-Hungary, which owned 1,052,000 tons of steel and iron sea-going ships in June, 1914, has now entirely ceased to exist as a maritime nation, and the 654,000 tons of shipping left to Germany is only a little more than one-eighth of the pre-war tonnage owned in that country. The German merchant fleet in 1914 had a tonnage of 5,098,000, being second only to that of the United Kingdom and nearly three times that of the United States.

If the above-mentioned figures be added up it will be found that the sea-going steel and iron self-propelled tonnage owned by the principal maritime countries of the world is now 54,217,000 as compared with 42,514,000 tons in 1914. The increase of 11,703,000 tons thus amounts to about 27½ per cent. of the pre-war total, and it should be noted that the nations which have increased their merchant fleets by more than this proportion are the United States, Japan, Italy, France, Holland and the British Dominions; Spain, Norway, Denmark, Sweden, and the United Kingdom have all increased their fleets by a proportion smaller than the average, while Germany and Greece own less than they did in pre-war times and Austria-Hungary now owns none at all.

From a further analysis of the statistics published in the Register Book some interesting information as to the development of oil fuel for ship propulsion, both for firing steam boilers and for use in internal-combustion engines, can be obtained. It appears that in 1914, 364 steamers with an aggregate tonnage of 1,310,000 were fitted with oil-fired boilers, whereas, at the present time, there are no less than 2,536 vessels so fitted, and their total tonnage amounts to 12,797,000. The latter figure, it may be noted, represents rather more than one-fifth of the total tonnage now in existence (20·65 per cent. to be exact), whereas the proportion in 1914 was only 2·62 per cent. With regard to internal-combustion engines for ship propulsion, the development which has occurred during the last seven years, although not so striking as that of oil firing, is nevertheless material. In 1914, 290 vessels driven by oil engines were included in the Register, and the aggregate tonnage, at that time, amounted to 234,000, so that the average tonnage of each motor vessel was just over 800. To-day there are 1,447 motor-driven ships in existence with a total tonnage of 1,263,000, and the average tonnage has therefore increased to about 875. Oil-engined ships now form 2 per cent. of the world's total tonnage, as compared with 0·47 per cent. seven years ago. The proportion of sailing vessels has fallen from 7·95 per cent. to 5·05 per cent. during the period we are considering, and the proportion of coal-fired steamers from 88·96 per cent. to 72·3 per cent.

Finally reference may be made to the large increase in the number and tonnage of vessels used for the transport of oil in bulk which has occurred during the period under review. The number of tank steamers registered in 1914 was 385 and their total tonnage was 1,479,000. The tonnage now on the Register is nearly three times as great, being 4,419,000, and the number has increased to 861; many of these vessels are, of course, propelled by oil engines. If from the present number we exclude 130 vessels, each of under 2,000 gross tons, which are mainly used for local trade, the

average tonnage of the remaining 731 could be 5,875, but the number includes 55 vessels of between 8,000 tons and 10,000 tons each, and 37 of still larger tonnage. From these figures it will be found that more than 7 per cent. of the world's total shipping is now employed in the transport of oil in bulk, whereas the corresponding proportion in 1914 was less than 3 per cent.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 99.)

HAVING dealt with the Engineering, Aerodynamics and Tank departments of the Laboratory, we now come to that devoted to metrology.

Metrology Department (Superintendent, Mr. J. E. Sears, M.A.; Principal Assistant, Mr. S. W. Attwell; Senior Assistant, Mr. F. H. Rolt; Messrs. E. G. Constable, F. A. Gould, V. Stott, G. A. Tomlinson, A. J. C. Brookes, W. H. Johnson, W. G. Ridge, J. S. Clark and H. P. Bloxam).—Exclusive of gauges for the Ministry of Munitions and taxi-meter tests, the number of routine tests increased during the year 1919–20 by nearly 4,000 to a total of 20,915, the chief work being in connection with screw gauges and glass vessels, though the work relating to the standardisation did not come up to anticipation.

Pure Measurements. Line measures. Surveying Tapes.—Some slight discrepancies between the determinations made in Sèvres and at Teddington of the length of the nickel metre bars No. 16 and No. 184 (the latter bearing two main metric intervals) still remain obscure. Although the discrepancy in the first case amounts only to 1·2 μ, the difference is outside the limits of errors of observations. The invar bar (36 per cent. of nickel) No. 27 shows a slight growth. One of the difficulties of such exact determinations lies in the temperature measurements. It is difficult to determine the exact temperature of specimens, and the mercury thermometers used are found not to be reliable within 0·01 deg. C.

The discrepancy between the Bureau des Poids et Mesures at Sèvres and Teddington also extends to the 24-m. standards (four invar tapes, four nickel tapes (43 per cent. of nickel), six invar wires), and half of these standards have been sent over to Sèvres. The 50-m. tape has not increased in length by more than 1:1,000,000 in four years. Forty-nine tapes were submitted for measurement.

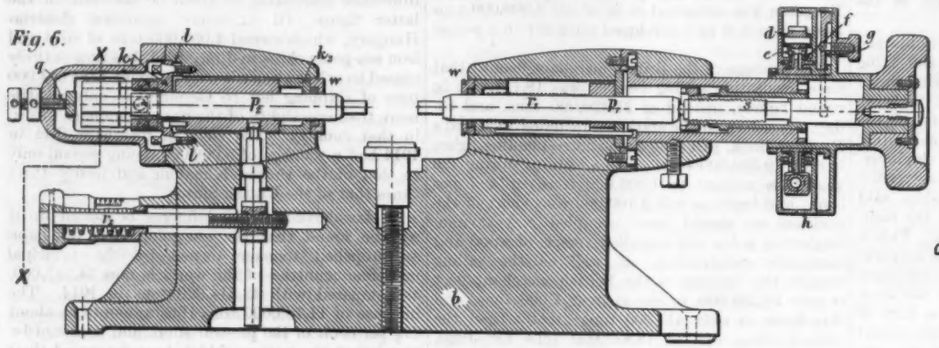
The 50-m. Base.—The periodical observations of the bench marks of the 50-m. base (brickwork) had been interrupted since March, 1915, but have now been resumed. The bench still continues to increase in length at the rate of 7 parts in 1,000,000, which is the same rate as for the five years before 1915. The careful relevelling of the bench shows that no local sinking has taken place in the bench marks since blocks bearing the reference marks were inserted in 1909. The length observations of the bench are now checked in an interesting way. Two invar wires, previously tested and found to be practically devoid of temperature coefficient, are stretched horizontally along the bench, the one close to the edge, the other lower down; the one wire has a length of 24 m., the other of 50 m. The fixed wire ends are provided with micrometer adjustments, which, once set, are not further used as a rule. The wires sag a little, of course, and the sag varies with the length of the bench, due to temperature and seasonal and secular alterations. This sag now is measured by micrometer screws mounted vertically at the middle of the wires. An accuracy of nearly 1 in 10,000,000 can be obtained.

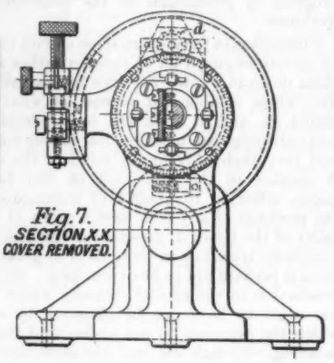
End Measures. Slip Gauges. Straight-Edge.—Almost all the 800 plain cylindrical and ring gauges submitted by one firm passed the Laboratory test, after the first batches of ring gauges had been rejected as too small for a reason which deserves mention. The makers were lapping the rings out until it became possible to insert a plug gauge; they were not realising that it is, under certain conditions of lubrication, possible to insert a plug in a ring which is actually smaller than the plug. In investigating this peculiarity in the Laboratory, a hardened steel ring was ground and lapped out to an internal diameter of 1·00000 in., as determined on a measuring machine. The outside diameter of 2 in. was ground true; a plug gauge was then lapped down until it could be inserted, using ordinary hand pressure, with both the parts quite free of grease. The plug diameter was found to be 1·00000 in. A second plug was then made, of diameter 1·0002 in. This would not enter the ring, but did when lubricated with vaseline, and it was ascertained that the ring was actually stretched by the plug inside it. This stretching is facilitated by a very slight taper, very common in cylindrical plugs.

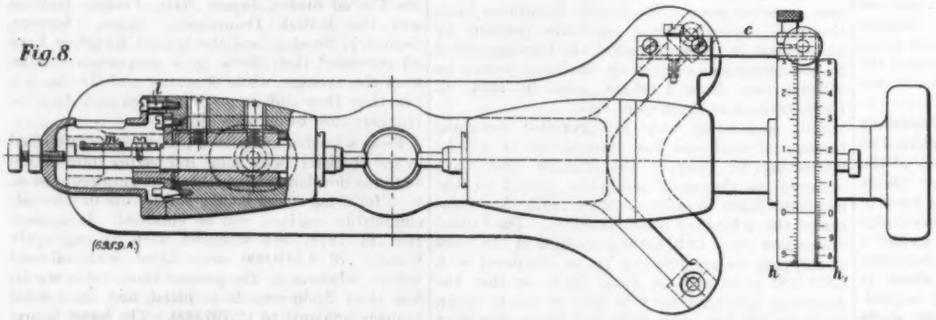
The war wear of small-length gauges of the Laboratory has necessitated renewal of several and their re-testing by the slip-gauge comparator was mentioned last year. Several additional sets of slip-gauges of foreign make, acquired during the war, were not found to be as constant as those originally bought in 1908. Hardened steel is liable to change its dimensions in the course of time, owing to internal strain, and the changes may be of either sign.

Slip gauges were used also in determining the straightness of a workshop straight-edge of 72 in. length, 3·05 in. by 0·125 in. in section, to find out whether this edge remained straight when supported only at the ends or at the centre. Supported on a narrow face at each end it was found to sag by 0·0043 in. at the centre; supported at the centre the flexure amounted to 0·0025 in. at either end; supported at Airy points ($72/\sqrt{3}$) in. apart, the sag was 0·0002 in. in the centre; supported symmetrically, the supports being $72 \times 0{\cdot}554$ in. apart, the sag was only 0·0001 in. There was thus noticeable sag in the first two cases, so that a bed, assumed to be straight, might really be hollow or cambered. In these tests different gauges were slipped under the edge while resting on a plane surface.

Small End-Measuring Machine.—Two small end-measuring machines of the type illustrated in plan and elevation and in sectional elevation, with cover removed, in the diagrams Figs. 6, 7 and 8, Figs. 9 and 10 showing further details, have recently been added to the Laboratory. They were designed by Mr. E. M. Eden, late of the Laboratory, but differ from other ingenious machines of his which we have described on former occasions. The base *b*







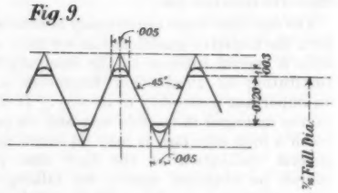


Fig. 10. DEFLECTING MIRROR SUPPORTED ON THREE FLEXIBLE STRIPS.

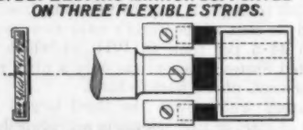
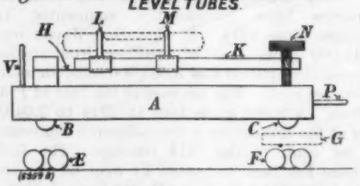


Fig. 11. APPARATUS FOR CALIBRATING LEVEL TUBES.



of the casting has a length of 12¾ in. It carries on the right-hand side a micrometer screw *s*, 0·4255 in. effective diameter, of 50 threads per inch (shown in enlarged view in Fig. 9), acting on the plunger p_1, and on the left side the plunger p_2, which rests against an adjustable dead stop *q*, and operates an optical indicator. The one measuring face is formed by the outer end of p_2, the other by the end of p_1, which is in contact with the micrometer screw *s*, but prevented from rotating. The micrometer spindle is fitted with a dial h_1, graduated to read to 0·0001 in. There are two other dials on the micrometer head *h*, and by the aid of an internal epicyclic gearing in these dials it is possible to read direct, without having to take an independent reading of the total number of complete turns of the screw which in ordinary practice have to be added to the reading on the graduated scale. The gearing comprises the corrector bar *c*, the 10-tooth pinion *d* working the sleeve clamped with the micrometer drum, two wheels of full diameter 2·318 in. and pitch diameter 2·227 in., the one *e* cut with 50 teeth, the other *f* with 49 teeth, and the clamping plate *g* for connecting the centre disc with the outer micrometer disc for repetition reading.

Contact between the micrometer screw *s* and the plunger p_1 is maintained by the helical spring r_1; spring r_2 presses plunger p_2 forward through the action of a lever, and this pressure can be altered at will so as to vary the pressure between the faces. In order to secure parallelity of the measuring faces of the machine, an adjustment has been provided at the rear end of the indicator plunger p_2 for slightly tilting it in any direction. The bush at this end consists of a plate *k*, which by the four conical-headed screws *l* is attached to the casting; by adjusting these screws the plate can be slightly displaced laterally; the bush k_2 at the front end is made sufficiently short to allow the plunger to cant. The rear end of the plunger operates a deflecting mirror *m*, which is supported on the double strip principle, Fig. 10. The thin steel strips on the one side of the plate are attached to the casting of the machine, the other strip is fixed to the rear end of the plunger. Movement of the plunger causes the mirror to tilt; above the mirror are mounted a lamp and a second mirror (not shown) and the beam reflected by the first mirror is sent down by the second mirror to a graduated scale; a scale deflection of ½ in. corresponds to a plunger movement of 0·0001 in. The *w* are washers to keep the dust off the inner parts.

Ring-screw-gauge measurements.—On the day when the Laboratory was thrown open for inspection, Mr. Sears demonstrated the use of another interesting novelty of his own design, a machine for measuring the internal effective diameter of a ring-screw-gauge with the aid of a ball-ended rod shorter than the diameter. The ring is held vertically, and the rod is displaced from the lower horizontal position in the ring-screw-gauge to the upper horizontal position; the effective diameter can be deduced from the displacement, with an accuracy of 0·00001 in. The same method is used for determining the internal diameters of plain rings; we hope to illustrate the machine in an early issue.

Flatness of End Faces of Gauges.—Mr. Rolt showed on the inspection day the use of two simple optical arrangements for testing the finish of the end faces of gauges. The two faces of a cylindrical rod should be plane, parallel and true with respect to the longitudinal axis. In the first arrangement the gauge is mounted so that it can be turned about that axis; the inner gauge face almost touches a proof plane of glass, leaving a gap of perhaps 0·5 mm.; the proof plane can be turned a little about its horizontal axis. Monochromatic light (green) is directed on the gauge face. Under ordinary conditions, *i.e.*, when the gauge is not really flat, a system of interference rings will be seen, and the centre of the rings will wander when we turn the gauge about its longitudinal axis; from the radii of the rings the camber can be deduced. When we replace the faulty gauge by a perfectly flat gauge of the Laboratory, the field will appear homogeneous without rings. When we then tilt the proof plane, the field will show interference bands, and these bands will travel across the field as we turn the gauge; by counting the number of bands and the rate of their disappearance one can estimate how the face oscillates backwards and forward if not normal. The other device tests only the parallelity of the end faces. The gauge is placed on a horizontal plate which rotates in its own plane. The observer looks through a telescope down upon the face and watches a spider's web which ought to remain stationary between two cross wires as the plane is rotated. If the web shifts to the right and left, the face is not horizontal; the shift can be measured, and calculations be based upon the measurement. The two apparatus described can be used for checking one another.

Calibrating Level Tubes.—An apparatus made in the workshop for calibrating level tubes is illustrated in Fig. 11. The base of the steel bar is fitted with two ¼ in. steel balls B and C, 12 in. apart; B rests on three similar balls, E, fixed to the surface plate in the form of a triangle; the guides (not shown) of the vertical bar V prevent the bar from falling sideways, and the pin P works in a vertical slot. By raising this pin the bar can be made to pivot about the centre of B. The brass bar K is hinged to A by means of a steel strip H and can be tilted slowly by means of the differential screw N; K carries two adjustable V rests, L and M, for supporting the level tube to be tested. Underneath the ball C are three balls F, and slips G can be inserted between C and F. By adjusting the screw N the bubble in the level is made to travel to the end of its range when one slip G is in position; this G is then replaced by another, 0·001 in. thicker, and the movement of the bubble is noted. From the dimensions of the apparatus and the travel of the bubble in tenths of an inch for a gauge thickness of 0·001 in. the radius of the tube can be deduced in hundreds of feet. Generally, the travel of the bubble will vary with its position along the tube, showing that the radius of curvature is not uniform. Level tubes up to 600 ft. radius have satisfactorily been tested in this way.

For the rapid levelling of tables, &c., Mr. Sears is making use of the following simple arrangement. Two mercury cups, shallow cylindrical steel basins, each surmounted by a vertical micrometer screw, are connected by a rubber tube. The one cup is kept in a fixed position, say in the centre of the table; the other is shifted about to different positions; as soon as contact is made between the mercury and the screw above it a telephone circuit is closed. Oscillations of the mercury have, of course, to be avoided, and for this purpose the depth of the mercury in the cup is made very small.

Glassware, Weights, Chronometers and Watches.—The methods of calibration adopted in the section dealing with the standardisation of glassware (Mr. Stott) were described by us last year. The standards of mass of the Laboratory consist of white bronze (copper-nickel) weights and of a set of rock-crystal weights, from 200 grammes to 1 gramme, which has been compared with the Sèvres standards. The number of watches and chronometers submitted for tests has increased again, but the numbers (266 and 54) are far below those of 1913–14 still. The best watch was again one made by Paul Ditisheim, of La Chaux de Fonds, who obtained 96·9 marks, surpassing his own previous maximum of 96·2 marks (1918). On behalf of Captain Craig, of Hazlemere, the "quiet" electro-magnetic clock units for silent and balanced step by step driving or synchronising were examined; the arrangement is described as quite silent in action and very ingenious and applicable for every second or group of seconds.

Expansion of Concrete.—For testing the dilatation of concrete on behalf of the Office of Works, Mr. Sears uses blocks of 28 in. by 4 in. by 9½ in. The end faces of the blocks are armoured with steel plates on which pins are fixed. A rectangular steel frame, built up of two rods and two cross bars, rests on the pins at one end with a V and a point, at the other end with a V. The whole block and framing are immersed in the tank of a comparator, and a micrometer is attached to the end of the frame. The dilatation of the steel being known, the expansion of the concrete can be deduced.

Workshop.—The metrology workshop for the making of accurate gauges and other instruments was opened in May, 1920; the organisation admits of readily determining the manufacturing costs of every piece of work.

(To be continued.)

NOTES.

HYDRO-ELECTRIC DEVELOPMENT IN FORMOSA.

SOME information about important hydro-electric enterprise in Formosa has been furnished to the Department of Overseas Trade by Mr. G. H. Phipps, His Majesty's Consul at Yamsui, Formosa. The first utilization of water power in the island dates from 1902, when a company was formed to employ the falls on the River Shinten to supply power to the city of Taihoku. The scheme was early taken over by the Formosan Government and the first station was opened in 1905, being followed by a second in 1909. These two stations had a total capacity of 4,000 h.p. In the eight years following, three further stations were built to supply the more important towns. These early stations are to be followed by a much more ambitious development utilizing the water of the Dakusui River and Lake Candidius. This is the largest lake in Formosa and lies almost exactly in the centre of the island. It has an area of 6 square miles and lies at a height of 2,400 ft. The river is to be diverted into the lake and will raise its surface about 75 feet, the works involved including a waterway 12½ miles long. This will necessitate the driving of 12 tunnels of a total length of 19,364 yards and 6 aqueducts of a total length of 402 yards. Two dams are to be built on the western shore of the lake where the banks are low. The waters will leave the lake by a tunnel 2 miles long and will be piped down to the power station at Monpartan, the fall being 1,100 ft. A steady flow at the outlet of 900 cub. ft. per sec. is being figured on, and it is expected that a maximum of 100,000 kw. and a minimum of 65,000 kw. of power will be available. It is hoped later to construct a second power station some four miles below the first, operating on a fall of 465 ft. This will give a total power of 145,000 kw. and an average of 95,000 kw. The scheme is being carried out by a semi-official company, which has taken over all the Government's electrical undertaking. The date of completion of the works has been put at 1924, but it is expected that the actual date will be a year or two later than this. The ultimate intention is to transmit electric power all over the island, and the complete electrification of the Government railway is talked of.

INDUSTRIAL DISEASES.

In a highly interesting paper published in a recent issue of the Journal of the Society of Arts, Sir Kenneth Goodby (the medical referee for industrial poisoning) suggested that in many cases the prescription of the use in industries of special forms of poisons is unnecessary, and in the long run does more harm than good to the workpeople employed. He points out that the susceptibility of persons to different poisons varies enormously. To take a trivial instance—some people suffer from a rash if they venture to eat shellfish; and he notes another case in which a worker in a drug factory suffered from belladonna rash, although only exposed to traces of the drug. When he first fell ill, the man was suspended, recovered, and returned to the factory, where he was put on work in which to all appearance he did not come into any contact whatever with the drug, but in a few days he was again ill in the same way. He was again suspended, and again returned with the same result. It was finally found that it was the man's working clothes which were responsible, as they had retained sufficient traces of the drug to affect him whenever he resumed them. Susceptibility to T.N.T. also varies greatly. Before the war this compound was declared to be absolutely innocuous, yet when its manufacture was commenced on a large scale there were numerous fatalities amongst those handling it. It was found that inhalation of the dust had apparently no ill effect, but the poisoning was the result of an absorption through the skin. This discovery led to the introduction of a method by which susceptible people were prevented from engaging in this class of work. A little T.N.T.

rubbed on the hands of a susceptible person caused a typical reaction in his excreta, but without making him ill. In non-susceptible people no effect was produced. It is along this line that Sir Kenneth proposes to combat industrial diseases. Painters, for example, are commonly believed to suffer seriously from lead poisoning, but it turns out that they develop similar illnesses even when working with lead-free paints. It appears that it is the turpentine which is responsible, a conclusion which has been confirmed by experiments on animals. Sir Kenneth suggests that when a lad enters the painting trade he should be examined at the end of the first three months and again three months later. These examinations would show whether the trade was a suitable one for the particular individual in question. In most cases, it would be found that even if exhibiting signs of poisoning at the first examination, immunity would have been acquired during the next three months, and if not so, some other occupation should be sought. In short, a man may acquire immunity to industrial poisons just as he does to the bacterial poisons responsible for epidemics, but just as there are certain persons who take the same disease repeatedly so there are individuals who fail to acquire immunity against industrial poisoning. Moreover, a point emphasised by Sir Kenneth is that just as immunity may be acquired, so may susceptibility. The latter is, he states, often produced by minor ailments, such as a septic mouth, tonsilitis, or a chronic catarrh, maladies which do not themselves prevent a man from attending his work, but do reduce his powers of resistance to the dangers of his trade.

LITERATURE.

Wireless Telegraphy: (1) *Experimental Wireless Stations.* By PHILIP E. EDELMAN, E.E. New edition, revised and enlarged. London: Henry Frowde: Hodder and Stoughton, 1920. [Price 16*s.* net.] (2) *Wireless Design and Practice: Part I. Transmitters and Receivers. Part II. Practical Circuits.* By M. B. SLEEPER. London: Henry Frowde: Hodder and Stoughton, 1920. [Price 7*s.* 6*d.* net.] (3) *Wireless Telegraphy and Telephony: an outline for Electrical Engineers and others.* By L. B. TURNER, M.A., M.I.E.E., Fellow of King's College, Cambridge. Cambridge, at the University Press, 1921. [Price 20*s.* net.]

(1) THE rapid development of wireless telegraphy, both scientific and commercial, has induced many amateurs to attempt to master the principles that guide and to construct the apparatus that achieves such marvellous results. Text books need to be as various in design and aim as the capacity and equipment of those for whom they are written, and it would have been easy to have increased the list of works that have been planned to assist those interested in the varied directions that radio-telegraphy has pursued. The first book on the list is addressed mainly to those to whom the mechanical arrangements appeal with force, whose delight is in construction, and who welcome the opportunity for exercising their ingenuity. The aim of the author is to enable a reader to construct from the raw material a practical working plant, and he states that the theory and mathematics underlying the accomplishment of radio-communication are given in considerable detail. But this claim is hardly justified. To write down a formula without explaining how it is derived, or defining the physical concept, will hardly satisfy the class who want to apprehend the principles that have made wireless telegraphy the power it has become. We are far from saying, however, that the absence of rigorous mathematical deductions will defeat the author's purpose, or prove any drawback to the mechanic who follows the steps indicated. In the construction of apparatus it must be admitted, that the reproduction of a diagram supposed to illustrate the behaviour of radiating waves is of little assistance, and in general that it fails to convey any real enlightenment. Yet while it would have been thought very remiss to have omitted all reference to electromagnetic waves in space, the utility of the work would not have suffered. Such theory as is occasionally introduced is probably intended for those who, by keenness of application and love of experiment, might advance the progress of the science. Without the guidance of theory development is slow. An interesting example occurs in the case of the thermionic tube. Edison detected the unilateral conductivity between hot and cold electrodes so far back as 1883, but the significance of the discovery was not recognised till after the researches of Sir J. Thomson on the electron in 1897. From that date onward the work of Fleming, De Forest and Langmuir has revolutionised the methods, and enormously increased the availability of wireless. Nevertheless, the mechanician of to-day enters into the labours of those and a host of others, and need not trouble himself with the theory of the operations.

The author recognises the latent constructive energy of the amateur and would encourage it. To such an one, who wishes to construct his own apparatus, and can follow with intelligence the given instructions, the book should prove invaluable. The standard of workmanship is high, and tolerates no inadequate or inferior craftmanship, that will fail under the severe tests of actual practice. Everywhere is emphasised the educational value of the construction of apparatus, and the satisfaction to be derived from successful achievement, but restraint is advised when some mechanical device can be purchased on the market at a figure less than that at which the experimenter could produce it, though he gave his time gratis. On the other hand, the construction of certain kinds of apparatus is so instructive that it is desirable to make them, irrespective of cost. Among these the author mentions the hot wire ammeter, which he thinks could be made by many readers at a total expenditure of less than 25 cents, "while others will doubtless spend up to a few dollars on its construction." Personally we should hesitate to produce the instrument at the lower price named, but those who are capable of accomplishing these feats will find the method lucidly explained.

And here it may again be insisted, that the author is addressing the competent workman and not the dilettante amateur. It is the former that he hopes may be tempted to embark on experiments, with the result that he will introduce improvements that will materially increase the efficiency of practice. Therefore he is anxious to point out that the construction of a wireless station need not be made an expensive hobby. A serviceable 250-watt station can be provided for an outlay of about 30 dols. for the transmitter, and an additional 20 dols. for every additional 150 watts. But it goes without saying, that the cost of a station depends largely on individual tastes. "Some experimenters are able to construct and operate efficient stations which cost only a few dollars, while others less experienced or less fortunate may spend many times as much without better or even as good results." Evidently the author has a truly economical mind, and is one who glories in effecting his object at a small expenditure. Quite rightly he expects old photographic plates, thoroughly cleaned, to be utilised for condenser dielectric material, and similar economies to be practised if these low estimates are to be realised. For experimental purposes, he recommends as a condenser old bottles placed in a dishpan and filled two-thirds full with a solution of common salt and water, connections being made to the dishpan and to wires entering into the bottles respectively. "A large capacity," he assures us, "is possible by this makeshift arrangement, but the capacity can, of course, not be accurately determined." Lest the author's very serious purpose should be injured by these crude quotations, we hasten to say that on vital points he admits of no trifling. For instance, he insists everywhere on careful and thorough insulation at critical points, the necessity of good earth connections is not overlooked, and the student is warned against neglecting small capacities and inductances, which may be magnified into importance by the great frequencies used in wireless telegraphy.

By attention to such small details, Mr. Edelman is able to make a considerable advance into the practical processes operating in more complicated systems involving the use of continuous waves and modern methods of rectifying and amplifying. The Poulsen arc is passed over with too brief a mention, seeing the important position it occupies amongst wireless transmitting systems, though its pre-eminence is more marked in larger installations than those contemplated by the author. The vacuum tube for detecting, amplifying and generating current is treated in considerable detail, and the illustrations of circuits are instructive. Some attempt is made to explain the theory of the "characteristic curve," but more details are needed; and references to resistances that do not obey Ohm's law must be puzzling to the beginner without further explanation. Still the extent of the ground covered is remarkable, and great confidence is placed on the ability of the experimenter to follow the instructions. Nevertheless, it is recognised that the ablest may fail to achieve the object pursued, and a useful chapter is inserted suggesting remedies for the faults that are most frequently encountered. Some information, too, is provided concerning the system of time signals emitted from various observatories, and the transmission of meteorological reports from naval radio stations. This is all very practical and very useful, and should be appreciated by the amateur who is anxious to get the most from his apparatus. We earnestly hope that the work will encourage many to undertake the construction of practical stations, which will later become laboratories for the study of electric phenomena and the acquisition of further information.

(2) The object of the second book on the list is to supply a guide for ensuring correctness of design in planning wireless apparatus, and like the preceding is of an eminently practical character, mainly addressed to those who have some familiarity with telegraphic apparatus. The author openly declares "that the essential problems have been stripped of mathematics which are beyond the average experimenter." He thus deprives himself of a valuable machinery, but we fail to see how the rejection of this aid will assist any one "to build apparatus for a given performance." Signs are not wanting to suggest that he is inclined to undervalue the intelligence of his readers, otherwise he would scarcely offer them in his opening pages, a table giving the result of the division of a constant by a series of consecutive integers. A second table, also of very elementary construction, is likely to prove of little service, for the interpolation necessary in a particular case may be more troublesome than a direct computation. The formulæ given in this introductory chapter on frequency, inductance and capacity, may prove useful.

The practical work begins with the construction of aerials. The multiple coil aerial, as a receiver, might have been discussed more fully, as it is likely to have an important future in modifying the usual antenna circuit, at least in amateur sets. This coil possesses some distinct advantages, being small in bulk and highly directive. Used in connection with vacuum tube circuits and amplifiers, a high degree of sensitiveness can be reached. In the next chapter, receiving apparatus is considered, a division of the subject to which the author has devoted more attention than to transmitting circuits. Quaintly enough, he states that there is more to be said about the former than the latter, but he is right in asserting that the amateur would find more difficulty in constructing the necessary transmitting machinery. Much useful information is provided of a practical character and the winding of coils receives much attention, but we doubt if the amateur is well advised to try to wind his own coils. The efficiency of coils depends upon many factors, some of which defy complete explanation, and it is wise to avail oneself of the teachings of experience.

Naturally the valve detecting circuit comes under consideration, and a little more preliminary introduction would have been advisable to make the novice understand the revolution that this instrument has worked, the wide scope of its applications, and its boundless utility in every branch of wireless telegraphy and telephony. The filament, the anode, and the grid circuits are described with some care, but we should have been glad to have seen the salient points emphasised more fully. The so-called "valve characteristics" is a rather unfortunate term, for the matter here treated has nothing to do with what is generally understood by the

"characteristic curve" of a triode or crystal detector. We miss, too, any specific reference to cascade amplifiers. In the remaining chapters of the first part, the function of transmitters is treated, but so briefly that the author fails to do himself justice. The method of heterodyne reception would be hardly intelligible to a student approaching the subject without any other aid than that supplied here.

The second part of the book gives diagrams of practical circuits, graduated in complexity. The object is apparently to show the most judicious way of making connections and arranging the apparatus to produce a practical result. It is easy to commit errors in the simplest receiving circuit, though it consist only of an antenna, rectifier and the telephone. In a correct arrangement, capacity between telephone to earth would be without effect, but if the apparatus were incorrectly designed, such capacity would distune the antenna and lead to other troubles. It is to ensure the adoption of a well-ordered design that these typical circuits have been prepared, and they may very well serve for practical exercises in the laboratory.

(3) Every writer who produces a work on wireless telegraphy finds it necessary to explain for whom it is intended. This is necessary, as the subject has reached such dimensions that it is probably hopeless to produce a work which will present its many aspects in a suitable form to meet all requirements. The author explains, therefore, that the third book on our list, a model of close reasoning and luminous exposition, is addressed to a class intermediate between the operator and the specialist wireless engineer, in a word, to the electrical engineer who has never had occasion to study this particular branch of his general subject. The treatise may well interest another class, as yet hardly existent, namely, students in universities and technical colleges, who will be attracted to this subject by the demand for trained wireless engineers, which will arise in the near future.

The main topic selected for detailed treatment is the thermionic valve, or its later form of the triode, whose importance in every branch of electrotechnics is already established and whose services in the future cannot be approximately estimated. This subject is introduced by considering the phenomena of oscillating circuits, and the methods of producing high-frequency alternating currents. The various possibilities that this sensitive apparatus has brought within the scope of the engineer by the adaptations of the retroactive principle and the achievement of long-distance telephony form a fitting extension of the main subject. This curt statement may seem to offer but a small programme, but it is one that is adequately filled, and the result can be offered without reserve to all who are anxious to acquire clear and definite notions of the fundamental principles, whose application has rendered possible the development of radio-telegraphy: developments that are by no means exhausted. And with each advance and accretion of further powers come a new interest and a new fascination, due, as Mr. Turner reminds us, to the close juxtaposition of the great and minute or to the control of enormous forces by the skilful application of ingeniously-devised mechanism. When employing the ordinary electric line, the imagination readily grasps the possibility of supplying energy at one end of the line and receiving a corresponding large amount at the other end. In submarine telegraphy, no surprise is felt that only a small fraction of the power transmitted should be received, but in wireless telegraphy, the extent of the dissipation of energy is grasped only by those who know the facts, or have made the calculation. The author arrests attention at the opening of his subject by a small table, which expresses the loss of energy under certain familiar conditions, but the figures telling the loss in wireless telegraphy elude the imagination.

Another illustration of the smallness of forces at issue is given, which though perhaps equally baffling to the senses, may serve to indicate the care with which the wireless engineer has to watch the small capacities and inductances that are perhaps unwittingly created, and which are insignificant trifles to the "50-cycle engineer." When working with great frequencies, "a capacity of 1 microfarad may be very perceptible. This is the capacity in air between two parallel sixpenny pieces spaced about twice their total thickness apart, or between the earth and a distant sphere of about 1 cm. radius." With a wave-length of 100 "an inductance of 1 microhenry might be of equal importance and this would be provided by two or three close turns of wire round an ordinary glass tumbler."

	Watts Transmitted.	Watts Received.	Ratio.
Power line	Say 10^6	10^6	1
Submarine telegraph	5	5×10^{-7}	10^{-7}
Telephone	10^{-2}	10^{-6}	10^{-4}
Wireless telegraph ..	Say 10^5	10^{-8} to 10^{-12}	10^{-13} to 10^{-17}

But whatever the delicacy of construction, and however slight the interferences that disturb the results, scientific ingenuity has known how to cope with the one and to evade the other. The author explains how these ends have been accomplished mechanically and offers a physical interpretation for many of the phenomena. It would have been a pleasant task to have followed the progress, and traced the connections in the various detail from the time that Maxwell enunciated the principle of electromagnetic radiation, through the experiments of Hertz, to the work of Overbeck and Braun who demonstrated the possibility of coupled circuits, and made wireless telegraphy practical and successful. With the new century and under the stimulus of the war, advancement had been rapid in various directions. Max Wien furnished the quenched spark, since so successfully exploited by the Telefunken Company. The Paulsen arc, whose theory is not yet fully established, marks another stage and has proved of the greatest importance for long-range work. The Goldschmidt system and the Alexanderson machine have improved the possibilities of continuous wave telegraphy, developing later the purity of the heterodyne note, first suggested by Fessenden, but for its practical development awaiting the advent of the triode oscillator. This instrument, the work of many hands, and with whose early conception the name of Fleming will always be honourably connected, but which owes its present form to the investigation of many others, among whom Meissner, Langmuir and Ferrié stand pre-eminent, will find a place in every branch of electrotechnics concerned with the detection or measurement of small effects.

Even without the greater marvels and difficulties of telephony, this outline would have furnished forth a pleasant and attractive tale, but many writers have made it a theme and its repetition would not have done justice to the author's work. The originality of the treatise consists in the method of arrangement, the selection and skilful dovetailing of the varied materials, and the omission of non-essentials. The ground covered is thoroughly explored, and from first to last one is in the hands of a master. Principles are seen to stand out saliently, and the author has more than fulfilled his modest intention of enabling the intelligent reader to appreciate the problems which are presenting themselves and to read, if he so desire, with understanding, any of the discussions of those problems appearing in the technical press.

The Powering of Ships. By J. BERTRAM THOMAS, M.B.E., A.M.Inst.C.E. London: Scott, Greenwood and Son. [Price 25s. net.]

FOR some time after the introduction of steam navigation very little information was available on the subject of the resistance of ship-shaped bodies; the accumulated naval records of competitive sailing trials being of no use in the new conditions. Model experiments, which now bulk so largely with us, are entirely due to the inventive genius of the late Mr. William Froude. He was a member of a Committee of the British Association, which in the year 1869 reported on various qualities of ships, propulsion being one of the points dealt with. The committee proposed that the Admiralty should be urged to carry out towing experiments on a large scale for the purpose of establishing satisfactory data upon which theories of resistance might possibly be based and also from which might be made estimates of horse power suitable for new types of vessels.

Mr. Froude, in a masterly set of "explanations," amounting to a dissentient report, let it be seen that he had rediscovered Newton's "Principle of Mechanical Similitude"—now universally known as "Froude's Law of Comparison." He advocated small-scale experiments, and wound up his explanations by saying: "I contend that unless the reliability of small-scale experiments is emphatically disproved, it is useless to expend vast sums of money upon full-size trials, which, after all, may be misdirected, unless the ground is thoroughly cleared beforehand by an exhaustive investigation on a small scale."

This bore immediate fruit in the establishment of a model experimental station near Mr. Froude's residence at Torquay. Shortly after his untimely death it was reorganised for the Admiralty at Haslar by his son, Mr. R. E. Froude. It is still in full operation and is the parent of the many similar establishments in all the principle maritime countries of the world. The output of technical data is now of enormous quantity, much of it being kept confidentially, but a considerable quantity has been made public, being enshrined in the archives of technical societies and in the columns of technical journals such as our own. The scattered nature of such publications militates against ready reference, and make its effective use increasingly difficult as time goes on.

This difficulty is frequently alluded to in scientific meetings. In particular, it was mentioned in the Institution of Naval Architects in 1919, and as the preface of the present publication reminds us: "something should be done towards collating and condensing all this information into a simpler and more accessible form." This is undoubtedly true, and anyone who had both time and inclination to make a really good collation (as distinct from a compilation) of the published data would deserve everlasting gratitude from that portion of the technical world which deals with these questions.

Although the title of the present work is the "Powering of Ships," the book is almost entirely devoted to the fundamental preliminary of "Resistance," leaving untouched the further subjects of estimation of power, design of propellers, &c. Starting with a brief introduction the author introduces the reader to some of the difficulties of the general problem of resistance and its familiar division into the two parts known as frictional and residuary resistance; then follows a good account of Froude's experiments on surface friction, and the frictional and exponential constants are suggested for application to ships. We are then taken briefly through the stream-line theory, leading up to the "Law of Comparison," after which Mr. R. E. Froude's constant system of notation is described. The remainder of the publication mainly consists of the tabulation of an immense amount of detail, giving the results of "Series Experiments," by Froude, Taylor, Sadler, Baker, Semple, &c. In these experiments are shown many of the effects of the vast variety of modifications which it is possible to make in the exterior forms of ships.

While we cannot but be gratified at having this information collected, it is in respect to the presentation of this matter that the author falls short, in our opinion, of having produced a work of really high merit. The experimenters, whose work he has dealt with, have been laws unto themselves. Each has used his own method of recording data, and this was quite endurable when publication was separate and widely scattered, both as regards time and place; but when collected, comparison is necessarily invited, and the work suffers in consequence. No doubt it would have involved an immense amount of time and labour to have evolved complete order out of such a chaotic mass of material, but we think something more might have been done than now appears.

It is almost impossible to avoid allusion to the great inequality in the character of the diagrams; while some are very clear and well-drawn, others of equal importance are so indifferent that it is with difficulty that they can be read, and they detract in

consequence from their utility, even if appearance were immaterial. We trust these criticisms will not be misunderstood. Such a work as the present ought to be a real boon to a busy professional man; but to reach a really high standard of excellence as a collation, it should not be compiled so hurriedly as this work seems to have been. It should mean bringing all the experimental results dealt with into something approximating to uniformity of presentation, and with each diagram and table bearing its own mark of identity, so that possibility of errors of reference might be reduced to a minimum, even if they were not entirely eliminated.

In any future edition, we hope the author may be able to include information bearing upon the resistance of appendages to the hull—a matter of great importance in many cases. We might also ask that Tideman's data as to surface friction should receive a little elucidation; at present his figures simply appear as rivalling those of Mr. Wm. Froude, but their origin is unexplained, and no guidance whatever is afforded as to their relative value. Finally we would suggest that the value of the bibliography would be greatly enhanced if it could be extended to cover the publications of other societies, both home and abroad, in addition to those the author has already explored.

BOOKS RECEIVED.

United States Bureau of Mines. Tenth Annual Report by the Director of the Bureau of Mines to the Secretary of the Interior for the Fiscal Year ended June 30, 1920. [Price 15 cents.] *Miners' Safety and Health Almanac, 1921.* [Price 5 cents.] Miners' Circular No. 27. *Causes and Prevention of Fires and Explosions in Bituminous Coal Mines.* By EDWARD STEIDLE. [Price 20 cents.] Bulletin No. 117. *Structure in Paleozoic Bituminous Coals.* By REINHARDT THIESSEN [Price 80 cents.] Washington: Government Printing Office.

Smithsonian Institution. Report on the Progress and Condition of the United States National Museum for the Year ending June 30, 1920. Washington: Government Printing Office.

Madras Presidency. Public Works Department. Administration Report for the Year 1919–1920. Part II. *Irrigation.* Madras: Superintendent, Government Press. [Price Rs. 4–4–0.]

Directory of Shipowners, Shipbuilders, and Marine Engineers, 1921. London: The Directory Publishing Company, Limited. [Price 20*s.* net.]

Solvency or Downfall? Squandermania and its Story. By Viscount ROTHERMERE. London: Longmans, Green and Co. [Price 2*s.*]

Fire Prevention during the War. Being a Record of the War Work of the British Fire Prevention Committee. London: The British Fire Prevention Committee.

Textile Machine Drawing. By THOMAS WOODHOUSE and ALEXANDER BRAND. London: Blackie and Son, Limited. [Price 2*s.* 6*d.* net.]

Metallography. Part II. *The Metals and Common Alloys.* By SAMUEL L. HOYT, E.M., Ph.D. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 28*s.* net.]

Sewers and Sewerage. Sewage Estimates and Sewerage Requirements. The Components and Operation of Sewers. The Design and Execution of Sewerage Schemes, for Engineers, Surveyors, Draughtsmen and Students for Examinations in Sanitary Science. By H. GILBERT WHYATT, M.Inst.C.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Pneumatic Conveying. A Concise treatment of the Principles, Methods and Applications of Pneumatic Conveyance of Materials. With Special Reference to the Conveying and Elevating of Heavy Solid Materials, for Engineers, Works Managers and Students. By E. G. PHILLIPS, M.I.E.E., A.M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

The Location, Grading and Drainage of Highways. A Concise Discussion of General Principles illustrated by Current and Recommended Practice. By WILSON G. HARGER, C.E. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 10*s.* net.]

The Inland Water Transport in Mesopotamia. Compiled by Lieutenant-Colonel L. J. HAIG, O.B.E., R.E. Under the direction of Brigadier-General R. H. W. HUGHES, C.S.I., C.M.G., D.S.O., R.D. London: Constable and Co., Limited. [Price 21*s.* net.]

The Homeland Handbooks. Vol. XCI. *Worthing, with its Surroundings.* By J. LEE OSBORN. London: The Homeland Association, Limited. [Price 1*s.* 6*d.* net.]

WATER POWER PLANT: ERRATUM.—We regret that on page 134 of our last issue we described a catalogue recently issued by Messrs. Hay, Maryon and Co., Limited, 14, Bride-lane, Ludgate Circus, E.C. 4, as dealing with water power and wind power installations and plant, whereas it deals with water power only. Messrs. Hay, Maryon inform us that they are not in any way concerned with wind-power machines; the catalogue referred to deals with water turbines, Pelton wheels, governors, pipe lines, &c., and discusses various features of different types of plant.

RECONSTRUCTION OF EBURY-STREET BRIDGE, LONDON.

(*For Description, see opposite Page.*)

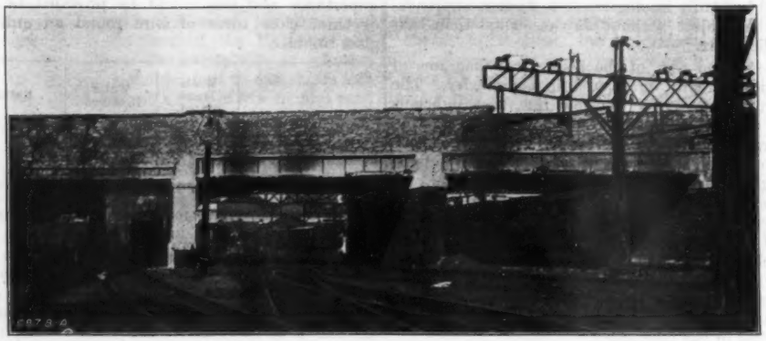


FIG. 1. THE BRIDGE AS RECONSTRUCTED.

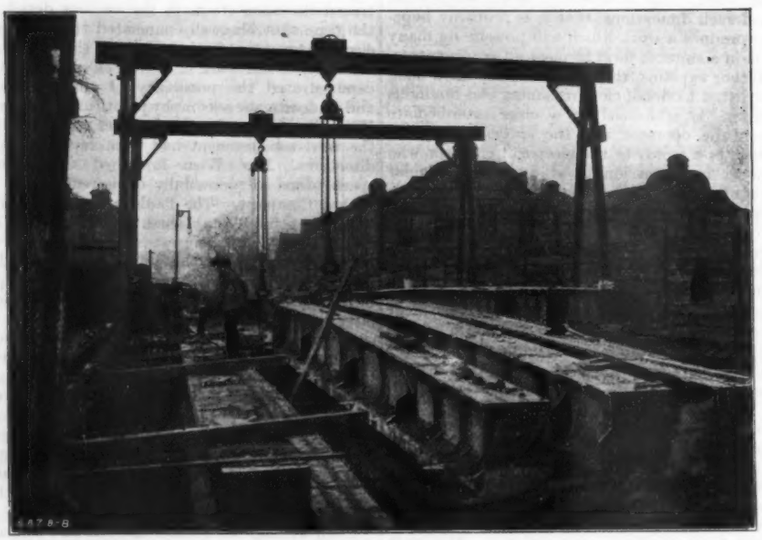


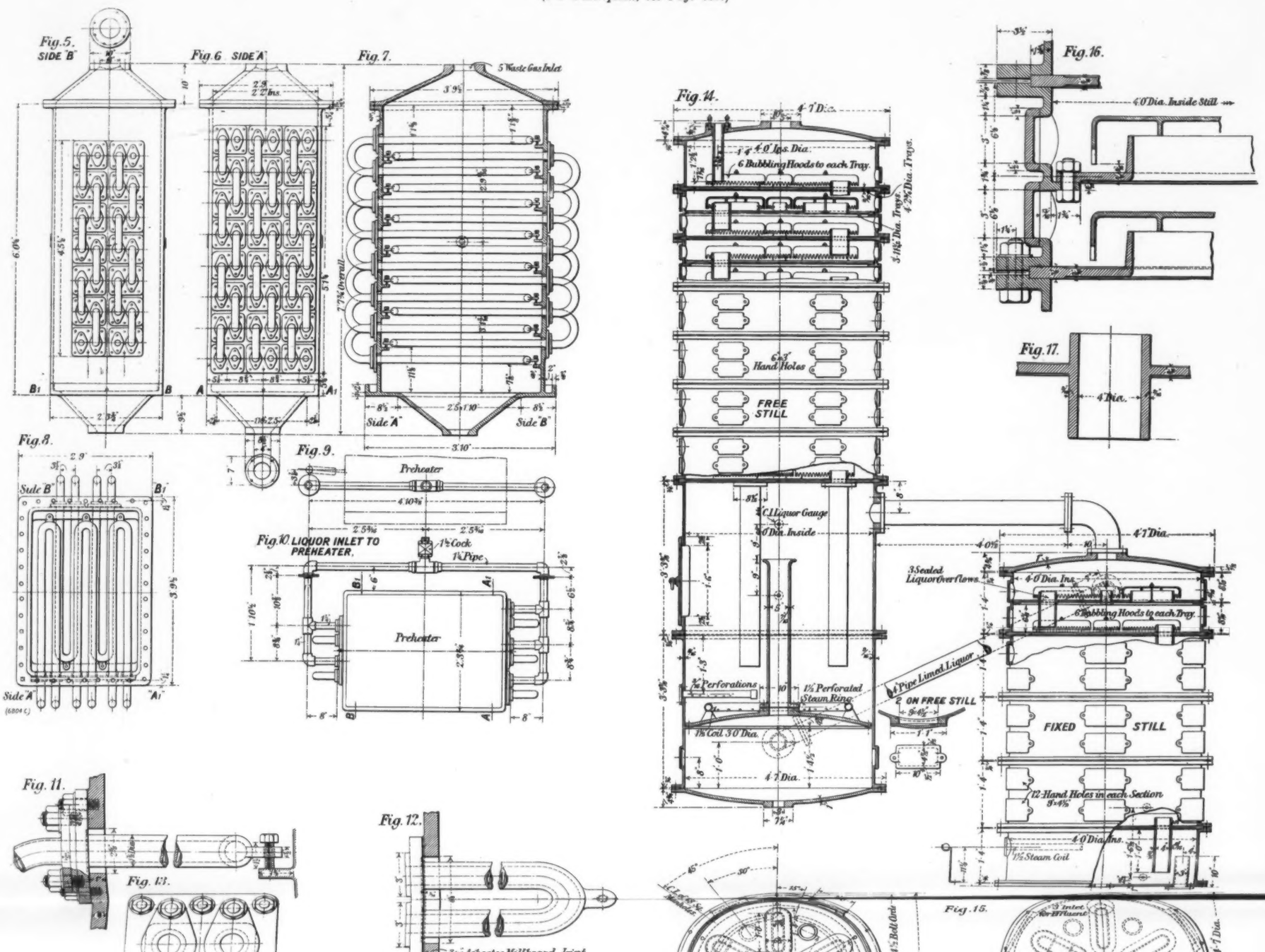
FIG. 2. NEW GIRDERS WITH TROUGHING IN PLACE ON BOTTOM FLANGE.

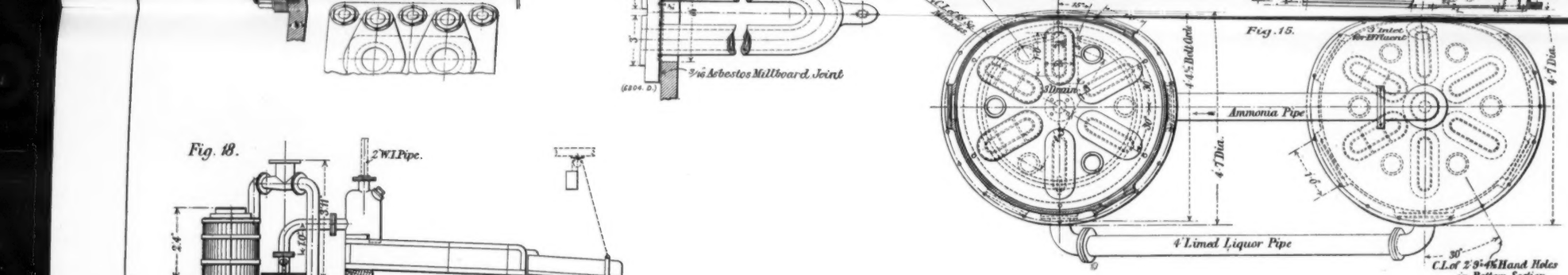
FIG. 3. NEW GIRDER BEING PLACED AND SHOWING BUILT-UP CONCRETE SKEWBACKS.

SULPHATE OF AMMONIA PLANT AT LEAMINGTON GAS WORKS.

CONSTRUCTED BY MESSRS. THOMAS PIGGOTT AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 135.)




3/16 Asbestos Millboard Joint
Fig. 15.
3" Inlet for Effluent
3 Drain
Ammonia Pipe
4'7 Dia.
4'7 Dia.
4 Lined Liquor Pipe
30"
C.L of 2'3-4% Hand Holes in Bottom Section.

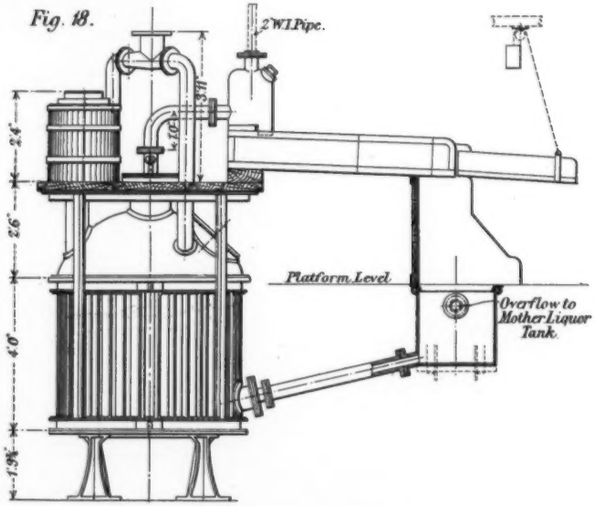


Fig. 18.
2" W.I Pipe.
Platform Level
Overflow to Mother Liquor Tank.

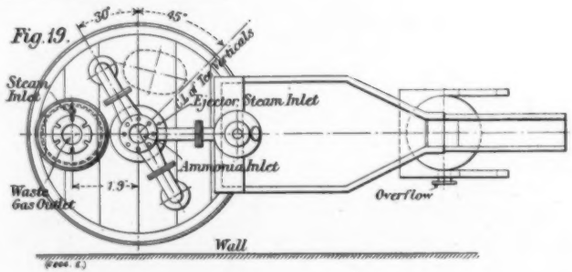


Fig. 19.
Steam Inlet
Ejector Steam Inlet
Ammonia Inlet
Waste Gas Outlet
Overflow
Wall

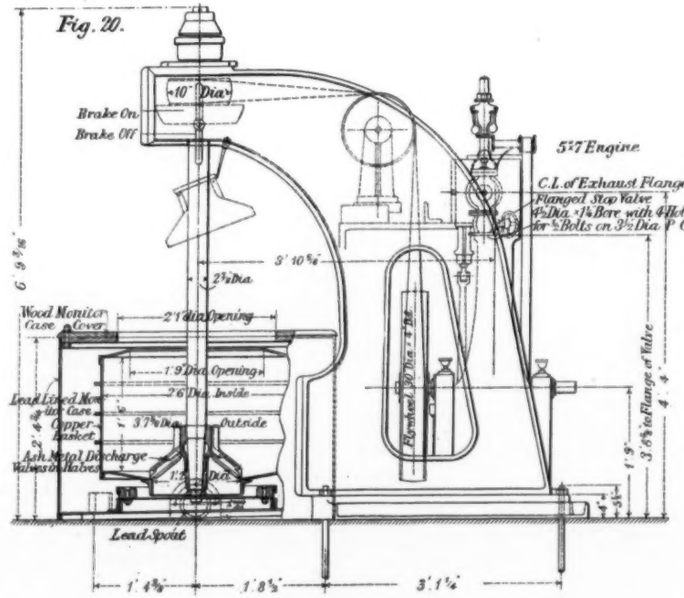


Fig. 20.
10" Dia.
Brake On
Brake Off
5"x7 Engine
C.L of Exhaust Flange
Flanged Stop Valve
Wood Monitor Case & Cover
2'1 dia Opening
1'9 Dia. Opening
2'6 Dia. Inside
Outside
Lead Spout

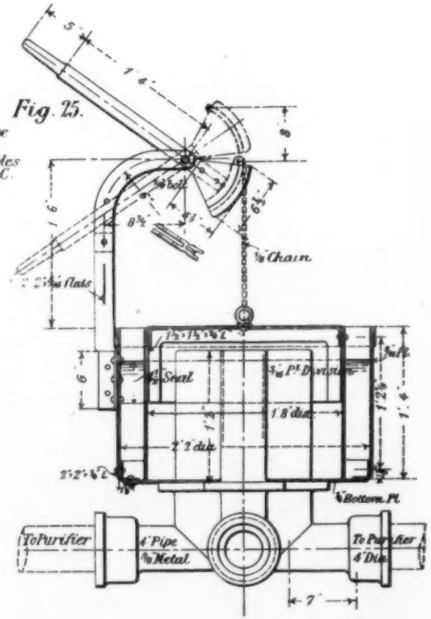


Fig. 23.
Bolt
Chain
Seat
To Purifier
Pipe
Metal
Bottom Pl.

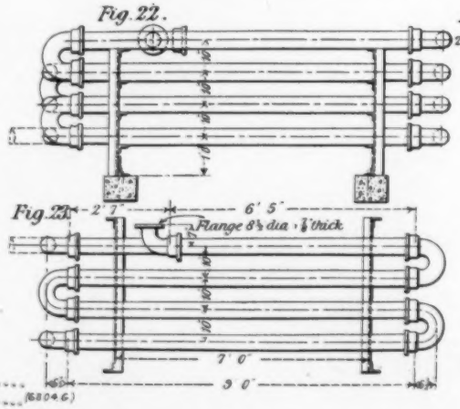


Fig. 22.
Fig. 24.
Fig. 22.
Flange 8½ dia. x ⅝ thick
7' 0"
3' 0"

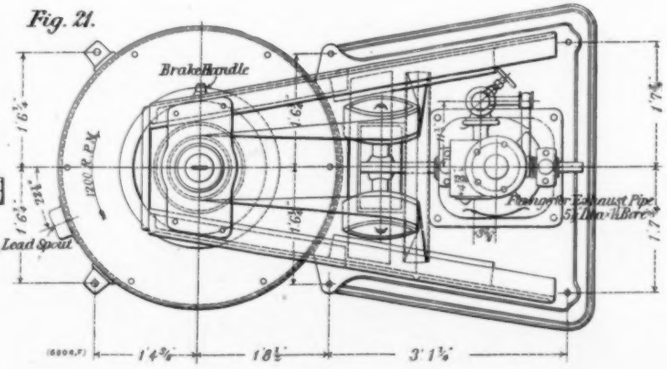


Fig. 21.
Brake Handle
Lead Spout

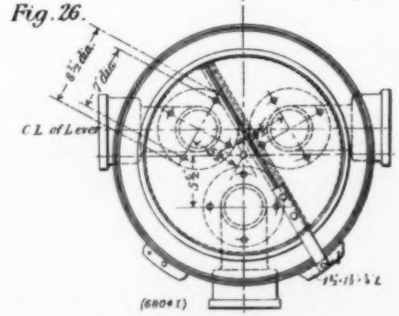


Fig. 26.
C.L of Lever

RECONSTRUCTION OF THE EBURY-STREET BRIDGE, LONDON.

Fig.4. LONGITUDINAL SECTION ALONG CENTRE OF ROADWAY LOOKING NORTH.

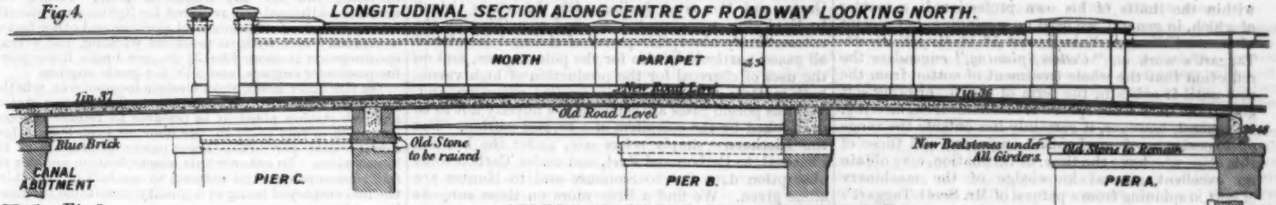


Fig.5. CENTRE OF MIDDLE BAY LOOKING EAST.

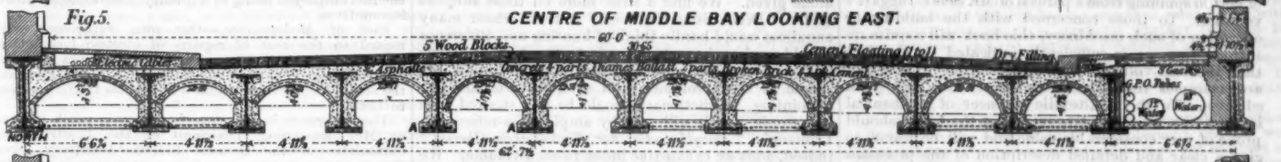


Fig.6. SECTION AGAINST ABUTMENT NEXT S.E.&C.RY LOOKING EAST.

Fig.7.

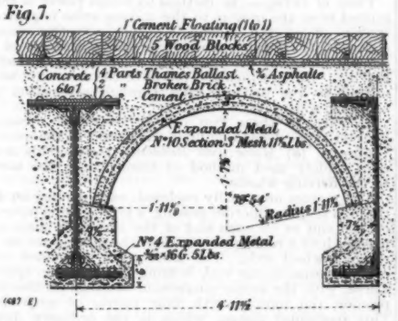
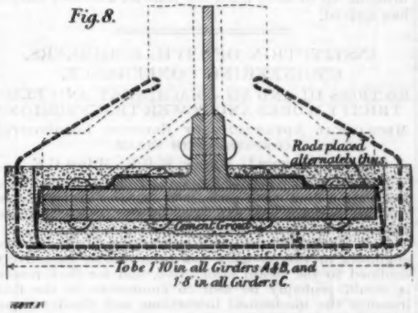


Fig.8.



A PIECE of reconstruction work of considerable interest owing to the peculiar conditions under which it had to be carried out has recently been completed in the rebuilding of the Ebury-street Bridge outside Victoria Station and leading from Buckingham Palace-road over the London, Brighton & South Coast Railway. The bridge is one of three spans of straight girders. Two of the spans are 45 ft. in length and cross the up and down main lines of the London, Brighton & South Coast Railway. The third span has a length of 36 ft. and crosses the railway company's sidings and engine roads.

As is well known, the main lines are equipped with 6,000-volt overhead wires, attached to the underside of the bridge, and the electric and steam services together result in trains passing on one or other of the lines at intervals amounting to seconds only in some cases, while on the engine and shunting roads the operations are continuous. The work was accomplished without any interference with the railway operations. With regard to road traffic, as the bridge is an important main road carrying heavy vehicular traffic, the Westminster City Council imposed very stringent regulations on the railway company, allowing only one half of the bridge and one footpath to be closed at a time, and imposing a penalty of £25 for each day in excess of the five months allowed for the rebuilding operations.

The roadway is 60 ft. wide, and the bridge carries the General Post Office telephone mains, electric light mains, and two water mains across the railway. The latter are 12 in. and 18 in. in diameter carried under the footways, and these had to be replaced by riveted steel pipes. The slopes at either end of the bridge are very inconvenient from a construction point of view, and in the rebuilding the road level at the crown was only allowed by the Westminster City Council to be raised 12 inches. Little, therefore, was possible in the way of re-design to bring about uniformity of component parts, and as a matter of fact every one of the 39 girders was of a different shape from the others, while the jack arch work varied practically throughout the bridge.

We illustrate the bridge as reconstructed in Fig. 1, on the opposite page, and Figs. 2 and 3 show the work during its progress. Fig. 4 to Fig. 8 above give drawings which show details of the work. Decided upon prior to 1914 the designs for the rebuilding were drawn up by Mr. C. L. Morgan, C.B.E., M.Inst.C.E., then engineer to the railway company. The steelwork and pre-cast concrete work was ordered, and reconstruction had actually been commenced by the railway company's own staff, when the war intervened and operations were suspended. Subsequently, the railway company abandoned the idea of doing the work themselves, owing to changed conditions of labour, &c., and the work was entrusted to the firm of Messrs. Sir Robert McAlpine & Sons, 50, Pall Mall, S.W. 1, whose proposals for carrying it out were approved by the late Sir James Ball, Engineer-in-Chief to the railway company, with the result that operations were started on October 18, 1920.

The bridge is a skew bridge, and each span is made up of 11 girders with two parapet girders, the spaces intervening, except on the extreme southern side, being completed by jack-arching. The one exception referred to is under the sidewalk, where a rectangular passage is arranged for the water mains and telephone cables. In reconstruction the clearance under the bridge was increased by an amount which in the centre span and eastern spans amounted to 12 in. This was accomplished by placing new bedstones on the eastern abutment, and introducing additional brickwork under the bedstones of the two island piers. At the western abutment a 3-in. course of blue brick was placed over the existing bedstone. Fig. 5 gives a cross-section of the bridge through the centre span, on Fig. 6 a section near the eastern abutment. These two drawings show the variety of the girder sections which had to be adopted. Fig. 7 shows a detail of the construction to a somewhat larger scale, while Fig. 8 is also an enlarged scale drawing of the bottom flange casing.

The girders are completely protected in the new bridge by reinforced concrete. Pre-cast troughs with reinforcing bars were fastened under the bottom flange, and the alternate reinforcing bars which projected on either side were bent over to clip the flange. These bars are shown by the heavy dotted lines in Fig. 8. The other reinforcing bars were, as also shown in this drawing, bent inwards to a slanting position in which they were embedded in concrete cast in place to form the skew-backs, after grouting had been run all round and over and under the bottom flange. The pre-cast troughing was in lengths of 3 ft., and was fitted and the grouting, &c. completed at the site before the girders were placed. The detail Fig. 7, shows the form of the skew-backs. These varied in depth practically throughout the bridge, though the dimensions sideways were maintained standard. These were also built up at the site on the girders before they were placed in position. Fig. 2 shows in the foreground a girder with the troughing grouted to the bottom flange, and the projecting reinforcing bars to be embedded in the concrete skew-backs may also be distinguished. On the left of Fig. 3 may be seen on the girder in the foreground being placed, the built-up concrete cast over the bottom flange. The actual girder shown in this view in the foreground is a parapet-girder.

By varying the height of the skew-backs it was possible to obtain some standardisation for the pre-cast sections of reinforced concrete jack-arching, as will be gathered from Fig. 5 and Fig. 7. The sections of jack-arching were supplied cast in lengths of 2 ft. 6 in. and were slipped into position between the girders from the ends, the end plates being left off to enable this to be done, and afterwards bolted up in place.

The method of erection required two travelling gantries running the whole length of the bridge, and spanning one-half at a time. These are well shown in Fig. 2, one track being laid in the centre of the bridge and one along the old parapet. The new girders were brought to the site by motor tractors and were unloaded and dealt with by the travelling gantries. The old girders, &c., were lifted out of position and loaded up by the same means. The new parapet girders were covered with expanded metal bolted to the steelwork and 2 in. of fine concrete, after which they were moved by the gantries to positions alongside the old girders. The gantry track was then removed from the latter, and the old girders were jacked up and carted away, the new girders being jacked into their place. These were the last girders to be placed, and the last of the jack arching was inserted by means of a lever mounted on a trolley running on a track laid on the completed portion of the bridge.

The space over the jack arches was filled with 1 : 2 : 4 concrete, broken brick and Thames ballast being used as the aggregate. This was laid to a depth of 6 in. over the arch crowns, was levelled off to give the correct grades, camber and slopes, and was covered with a damp course of ¾ in. asphalte, over which was a floating of cement 1 in. thick, upon which was laid 5 in. wood block paving. The bridge has new brick parapets over the parapet girders, and free stone coping.

The work was carried out during the winter months and was completed 20 days within the contract time, and without a single delay to traffic. The whole of the work was done in daylight, and from above the bridge. It is interesting to note that of the 60 men employed on the job no less than 48 were ex-service men, several of them having enlisted in September, 1914, in a special Bridging Company raised by Major F. Forbes Higginson, M.C., the engineer who was in charge of this reconstruction, for Sir Robert McAlpine & Sons.

THE WALDECK DAM.—The dam near Waldeck, to which the German engineers paid a visit during their meeting in the last week of June, is at present considered the biggest artificial lake basin in Europe. It has a length of 27 km. (17 miles), and a maximum width of 1·5 km. (1 mile), and a capacity of 200,000,000 cub. m. (7,000,000,000 cub. ft.) The dam rises in an arc of 305 m. radius (1,000 ft.) to a height of 48 m. (157 ft.), the thickness being 35 m. (115 ft.) at the base, and 5 m. (16½ ft.) at the crown, over which a roadway is taken. The water level may vary considerably. The lake has been created for a threefold purpose. Firstly to stop the frequent floods; secondly to supply the Weser Canal with water, and thirdly to create electric power through the intermediation of six double turbines of the Francis type, each of 3,900 h.p. maximum. With the lowest water level to be reckoned with only 570 h.p. would be available. The district supplied with power comprises the towns of Cassel, Göttingen and Marburg.

NOTES ON NEW BOOKS.

THE possible extent of the interests of an engineer within the limits of his own profession is a matter of which, in general, we need no reminding, but receipt of new editions of Vols. I and II of Mr. W. Scott-Taggart's work on "*Cotton Spinning*," engenders the reflection that the whole treatment of cotton from the raw until it exists in the form of calico, or other soft goods, lies within the sphere of mechanical engineering. In general, however, it certainly lies outside the range of experience of mechanical engineers, and those of this class who have the time, or inclination, may obtain an excellent general knowledge of the machinery of cotton spinning from a perusal of Mr. Scott-Taggart's volumes. To those concerned with the building or operation of such machinery, this book will require no introduction, as is sufficiently indicated by the fact that the two volumes with which we are concerned, are examples respectively of the seventh and sixth editions. To the non-textile engineer of mechanical interests we may say, however, that the books should prove of very considerable value and will be found to give a clear and detailed description of the processes concerned. They are excellently illustrated with diagrams and drawings, which give all essential details and clearly show the many somewhat unusual mechanical motions which have to be employed in connection with the various processes of cotton spinning. There is a notable absence of illustrations of the catalogue block order. The volumes form the first two of a series of three which cover the whole practice and theory of cotton spinning and are sold at 8*s.* 6*d.*, net each. They are published by Messrs. Macmillan and Co., Limited.

ONE of the difficulties which the manual worker has to face when he tries to improve his knowledge of his craft and raise his outlook from the purely manual to the technical is the difficulty of finding books that he can read with understanding and consequently with advantage to his skill. Those which he may find often treat the subject in too elementary a manner or they assume a knowledge of technical terms which he does not possess and discourage him in consequence. The skilled manual worker and the foreman have been forgotten very largely by the publisher, but if it can be brought to their notice there should be many such men waiting to welcome a book like "*Sheet Metal Drafting*," by E. M. Longfield (New York and London: McGraw-Hill Book Company, Inc. Price 12*s.* 6*d.* net), which deals with quite advanced drawing out work in a way which make the problems easily understandable to those whose acquaintance with technical terms has yet to be cultivated. The diagrams are excellent and clearly explain the methods used, so that hardly any reference to the text is necessary. Each chapter deals with some special shape or conic section and consists of problems fully worked out concerning the manufacture of particular articles whose shapes belong to the class being dealt with. Full diagrams are given showing the method of finding the expanded surface and useful notes are added in many cases showing the best utilisation of the sheets available when quantities are being produced. We are sure that sheet metal workers will find this book of very great assistance to them in their work.

So many works of reference have their value depreciated by the lack of adequate indexes that one in which this important matter has been carefully considered calls for special comment. In the *Directory of Shipowners, Shipbuilders, and Marine Engineers* for 1921, which has recently been issued, the two largest sections give lists of British and foreign shipowners and British and foreign shipbuilders and marine engineers. These lists are themselves arranged alphabetically in order of names, and, in addition, there is an index of names arranged geographically for each important country of the world with sub-headings for the various towns. There are also a personal index to the company officials, and an index to names of boats owned, both of which will help to save the time of the regular user. In addition to the two main sections above referred to the Directory gives particulars of Admiralty departments and officials, and similar information is given for the Board of Trade, Lloyd's Register, the British Corporation, and the Bureau Veritas. Lists of consulting marine engineers and naval architects and of technical and educational associations and institutions are also included in the work, which is published by the Directory Publishing Co., Ltd., Queen Anne's Chambers, Westminster, S.W. 1, at the price of 20*s.* net.

When we noticed, a few months ago, the first volume of the enlarged edition of Sir Edward Thorpe's "*Dictionary of Applied Chemistry*," we mentioned, among other omissions, the absence of the term "absorption." We pointed out at the same time that, with books appearing in consecutive parts, it would be unfair to criticise such apparent omissions which subsequent volumes might fill up. In the second volume of the Dictionary now before us (Longmans, Green and Co., 60*s.*) dealing with the words Calcuh to Explosion, we expected to find something on the extraordinary absorptive power of charcoal for almost all gases, particularly also for the poison gases, and on the uses of charcoal for the production of high vacua, both matters of importance in applied chemistry and, so far as poison gases are concerned, a novelty not to be overlooked by the compilers of a revised edition. But the Dictionary simply refers one, under the heading Charcoal, to Carbon and Fuel, and under Carbon some absorption data due to Saussure and to Hunter are alone given. We find a little more on these subjects under "Decolorising Carbons," a term which many enquirers would hardly think of hunting up. Reference should anyhow have been made to this further article under charcoal or carbon. But cross-references are sparse in these volumes, and such features are disappointing. A dictionary should be well stocked with key words, and it will gain by ample cross-references. Ullmann's "*Enzyklopadie der Technischen Chemie*" indeed, adds an exhaustive index to each volume. We do not insist upon this undoubtedly expensive though very useful addition. But more might have been done to facilitate the task of those consulting the dictionary. One feels, moreover, occasionally on looking through this publication, which rightly enjoys an unique position in this country, that technical dictionaries may need a periodical recasting in some sections rather than bringing up to date, when the time for a revised edition has arrived.

INSTITUTION OF CIVIL ENGINEERS.
ENGINEERING CONFERENCE.

SECTIONS III AND VII.—MACHINERY AND ELECTRICITY WORKS AND POWER TRANSMISSION.*

MECHANICAL ADVANTAGES OF ELECTRIC LOCOMOTIVES COMPARED WITH STEAM.

By Sir VINCENT L. RAVEN, K.B.E., M.Inst.C.E.

IN a comparison between steam and electric locomotives there are a number of prominent features in both types that are perhaps best expressed by the terms "for and against" or "advantages and disadvantages."

Admittedly, the practical experience of locomotive engineers in this country has been almost exclusively confined to the steam locomotive, and for that reason it would probably be well to enumerate in the first instance the mechanical limitations and disadvantages which, every engineer will agree, exist in the steam locomotive, and which, it may be argued, are overcome to a very considerable extent by the adoption of the modern and more up-to-date system of electric traction.

The mechanical disadvantages of the steam locomotive may be briefly summarised as follows: The locomotive being a complete independent unit, its power cannot be greater than the capacity of its boiler. To increase the boiler capacity obviously implies increased dimensions and weight, both of which offer grave difficulties in regard to clearances and strengthening of bridge structures. It is known that on many railways in Britain the limit of weight has been reached, and further development of power is only possible at enormous expense. The boiler, cylinders, valve gear, crankshafts and all reciprocating parts are costly to maintain. Turntables, fuelling plant and water supply appliances must be provided. The cab is small and open to the weather, involving discomfort to the locomotive crew. The locomotive radiates heat and uses coal all the time steam is up, that is during many hours when it is doing no work, and either standing by or coasting. The wear and tear of the locomotive on the track is considerably increased by the impossibility of accurately balancing the reciprocating parts. The case of the electric locomotive may be set out by the brief statement that it is not hampered by any of the above-mentioned objections. In addition, one might point out that it possesses other important qualifications such as: Simplicity of mechanical construction and operation; increased power of acceleration; higher scheduled speed due to the possibility of heavy short period overloads resulting in more frequent service and increased use of existing tracks; uniform turning effort resulting in better factor of adhesion at starting and on gradients; absence of all reciprocating movement and accurate balance of all rotating parts; facilities for driving from either end of a locomotive; accessibility of mechanical and electrical parts; better accommodation for locomotive crew by reason of increased cab area and by closing in and heating the cab; possibility of coupling two or more locomotives together under the control of a single driver.

Owing to the limitations of this Note, probably sufficient is here put forward to invite a full and exhaustive discussion, but two special points may be referred to, namely, the fuel economy made possible by the use of electric locomotives, together with maintenance costs, and the various designs of electric locomotives depending upon the method adopted to transmit power from the motors to the driving axles.

Fuel Economy.—The production of energy in a power station rather than on the locomotive leads to a very substantial economy of fuel. On a steam locomotive fitted with all modern improvements, it is not practicable to work at less than about 2¼ lb. of best quality coal per brake horse-power, and very few engines are capable of doing this for any length of time. Taking into account additional fuel required for lighting up, standby losses, periods of uneconomical working and other factors continually met with in practical working, the average consumption is more like 3½ lb. per brake horse-power for passenger engines, and 5 lb. for goods engines.

On the other hand, with electric locomotives, whether passenger or goods, and with up-to-date power station and sub-station plant, it is possible to reduce the consumption of fuel to 1¾ lb. per hour, or even less, of low-quality coal per brake horse-power produced on the locomotives. In other words, electrification enables the fuel consumption to be reduced to one-half or one-third, the fuel employed being of a quality unsuitable for steam locomotives.

Cost of Maintenance.—Our own experience with regard to the cost of repairs of electric locomotives working between Shildon and Newport, shows that this cost is approximately one-third that of maintaining the steam locomotives which worked this traffic previous to 1915.

The difference in America, however, is much greater, as Mr. Armstrong, chairman of the Electrification Committee of the General Electric Company, gives figures showing the cost of repairs per mile of three American railways varying from 6·3 cents to 14·6 cents as compared with a cost of 60 cents per mile for a 2-8-8-2 Mallet steam engine, which is the class of engine that would have to be used to haul a similar train to that taken by the electric locomotive, the cost of repairs of which is 14·6 cents, or one-fourth that of the steam engine.

Class of Drive.—The method by which power is transmitted from the motors to the driving axles is generally spoken of as the "drive." There are two general classes: (1) In which the motors are built direct on the driving axles, or are connected to them by reduction gearing. (2) In which the power of the motors is transmitted to the driving axles through connecting and coupling rods.

In each of these two classes there are numerous distinct types depending upon the details of the drive.

Class 1. (*a*) *Motor with Reduction Gear.*—This is the most widely used method of transmitting the torque to the driving wheels.

The motors are totally enclosed, each driving an axle through single-reduction gearing, a pinion being mounted on the end or on each end of the armature shaft, and meshed into a corresponding gear wheel, mounted on the running wheel axle. The motors are suspended by a cross suspension bar with bearings and reaction springs. These, with the motor suspension bearings on the axle, provide the motors with four points of suspension. This particular design, which is the ordinary double bogie articulated type, is widely used for freight traffic, and is the same as that used on the Shildon-Newport Electrification, North Eastern Railway, and other systems in the States and on the Continent.

(*b*) *Quill Drive.*—The motors are mounted rigidly between the frames. Each motor is geared to a quill centred in bearings in the motor frame, and surrounding the driving axle. The axle and quill are concentric. The quill is connected to the driving wheels by long helical springs which are clamped rigidly at the ends in castings which are bolted, one to the quill flange, and the other to the driving wheel. All springs with clamps are interchangeable, and any spring may be removed without disturbing any part of the running gear. The arrangement is such that the axle, quill, pair of wheels and motor can be removed from the locomotive without disturbing the running gear. This drive secures all the advantages of a flexible gear in cushioning the transmission of torque, and lessens the vibration more effectively than the usual flexible gear construction and mounting. This drive is employed on the geared locomotives of the New York, New Haven and Hartford Railway, also the Chicago, Milwaukee and St. Paul.

Advantages of Quill Drive.—(1) The driving wheels are large. (2) The centre of gravity of the locomotive is high. (3) The deadweight on the track is reduced to a minimum, consisting only of the wheels and axles, without the addition of any portion of the motors.

(*c*) *Gearless.*—The motors are of the bi-polar type, the armature being built directly upon the driving axles, and the other parts of the motor being built into the framework of the locomotive structure. This arrangement is such that any armature with its axle and pair of wheels can be removed from the locomotive without disturbing the rest of the motor. This design is in use on the Chicago, Milwaukee and St. Paul and the New York Central Railways, and is giving every satisfaction.

The advantages claimed for this design are: Simplicity of electric motor owing to the absence of motor bearings and gear, &c. Facility for examination of motor and removal of armature for repairs required. The mechanical arrangement of the complete locomotive is said to possess the required flexibility and balance to enable it to run at any speed equally well in either direction without tendency to oscillate or spread the track.

Class 2.—In this class the rotary motion of the motor armatures is transmitted to the axles by cranks on the motor shafts, or on jackshafts driven by the motors and by connecting rods coupling these cranks with crank-pins on the driving wheels.

The principal advantage of this method of drive is that the exact position of the motor in relation to the driving wheels is at the disposal of the designer, and he is therefore free from the restrictions imposed upon him by the necessity for getting the motors into the space between the flanges of a pair of wheels as in all locomotives of

* This and the succeeding notes were read at the Institution of Civil Engineers on Friday, July 1, 1921.

Class 1, and is therefore enabled to use large motors and place them in the most convenient position in the locomotive.

This method of drive has not been employed at all in this country, except for experimental purposes. In the United States there are a few examples, namely, the locomotives on the New York section of the Pennsylvania Railroad, others of a different design on the Norfolk and Western Railroad, and an experimental locomotive designed by the Pennsylvania Railroad for the electrification of the Altoona grade. The general opinion in the United States seems to be more in favour of designs which come under Class 1.

On the Continent, notably in France, Switzerland, Italy, Germany, Austria and Sweden, the connecting-rod drive in one form or other is almost universal. Up to the present electrification in these countries has been carried out mainly on the single-phase or three-phase system, and Continental engineers consider that the additional complications caused by the introduction of cranks and coupling rods are more than compensated for by the advantage of having a free hand with the motor design.

A large number of designs have been worked out. Some have proved quite satisfactory, others have given rise to a good deal of trouble. In most cases the trouble has been eliminated by strengthening up special parts such as crank-pins, Scotch yokes, &c., and by introducing a certain amount of flexibility into the connections between the motors and the crankshafts.

SECTION IV.—MINING AND METALLURGICAL PROCESSES.

The Effect of the War on Mineral Supplies.

By Thomas Crook.

The recent world war demonstrated the importance of national independence as regards mineral supplies for war purposes. In many countries new sources of supply were developed, some of which are likely to prove permanent, as, for example, coal in Nigeria and the Federated Malay States, manganese ore in the Gold Coast Colony, bauxite in British Guiana, Dalmatia, and Istria, and magnesite in Italy. Others, however, such as the tungsten and chromium mines of the United States and some other countries, have already ceased production owing to the partial restoration of normal economic conditions.

Reduced output of many minerals, due to withdrawal of labour and limitation of markets, was a striking feature. These conditions influenced the production, not only of minerals required mainly for agriculture and other peace-time industries, but also of some war-minerals, notably coal and iron ore, especially in Europe. Increased oil production compensated to some extent for decline in the coal output. In the case of iron it is worthy of note that although the output of iron ore and consequently that of manganese ore dropped very substantially, there was a remarkable increase in the output of nickel, chromium, vanadium and tungsten. The latter may be aptly termed "economy" metals, for the extensive use of nickel and other alloys no doubt effected much economy of material, while the remarkable increase in tungsten output must have had a very important effect in economising labour.

If time permitted it would be interesting to take various industries in turn, to see how the absorption of the world's energies in war activities affected them, and through them the supplies of the minerals they require. We should see, taking agriculture, for instance, that the consumption of phosphates, which are not directly important for war purposes, dropped to such a serious extent that special provision had to be made for imports into the United Kingdom. We might note also the reduced consumption of potash salts, the collapse of the German potash monopoly, and the remarkable developments now taking place in Alsace. Taking the chemical industry, we might consider details showing the vigorous efforts the world has made, and is making, to emancipate itself from dependence on Chilian nitrate, the reserves of which are still enormous. Again, we might note the remarkable increase in sulphur production in the United States, due to reduced imports of pyrites; and, in the same connection, Germany's successful efforts to obtain her necessary supplies of sulphur and sulphuric acid from mineral sulphates, such as anhydrite and gypsum.

In the time allotted, however, one can only touch on a few salient facts, and in the following notes, only coal, petroleum, and some of the more important raw materials of the iron and steel industry are mentioned. The ton of 2,240 lb. is used throughout.

Coal;—World's Output of Coal.

1913, 1,320,000,000 tons; 1919, 1,130,000,000 tons.

From 1913 to 1919 there was, on the whole, a decline in the world's output of coal, more especially the European output, and costs of production increased to a greater extent in Europe than in the United States. There were signs of more normal production in 1920, the world's output for which year is estimated at 1,300,000,000 tons. The world's total exports in 1919 were 43 per cent. less than in 1913, due largely to heavy reduction of exports from England and Germany. The United States total exports increased from 22,000,000 tons in 1913 to 39,250,000 tons in 1920, excluding bunker coal, shipments to Europe amounting to about 10,250,000 tons in 1920 as compared with less than 1,000,000 in 1913.

Petroleum;—World's Output of Petroleum.

1913, 55,000,000 tons; 1920, 98,000,000 tons.

Unlike most war minerals, petroleum has continued in ever-increasing demand since the armistice. The output for 1920 was about 80 per cent. more than that for 1913, and 36 per cent. more than that for 1917.

The United States output increased steadily from about 38,000,000 tons in 1913 to 63,000,000 in 1920; and the output for the first quarter of 1921 was more than 1,500,000 tons in excess of that for the first quarter of 1920, the March output establishing a new monthly record. The Mexican output increased from 3,000,000 tons in 1914 to nearly 23,000,000 tons in 1920, the production in the latter year being nearly double that for 1919. Outputs in Egypt and Persia increased from comparatively insignificant amounts in 1913, to nearly 250,000 tons and 1,000,000 tons respectively in 1920.

This remarkable progress in oil output, taken in conjunction with the decline in the coal output, raises the question as to whether oil is not likely, in the near future, to become as important as coal for power production. Oil reserves are regarded as very small in comparison with those of coal, but our knowledge of oil reserves is somewhat speculative. Moreover the world has large oil shale resources, and it is possible that these will be drawn upon to a large extent in the near future.

Iron Ore;—World's Output of Iron Ore.

1913, 175,000,000 tons; 1917, 145,000,000 tons.

Output of iron ore fell in most of the important producing countries during the war. Comparing 1917 with 1913, the outputs of the more important countries fell by the following percentages: United Kingdom, 7½; Newfoundland, 27; France, 90; Algeria, 27; Spain, 44; Germany, 21; Luxemburg, 42; Austria, 42; Hungary, 23; Sweden, 17; Cuba, 65. The United States increase of 21 per cent. was exceptional.

Since the armistice, output has fallen very heavily in the United Kingdom, Sweden, and some other countries. A fall of 2·3 million tons in the United Kingdom during 1919 more than offset the 1·3 million rise in 1917. The 1920 output in the United Kipgdom was 12·7 million tons, compared with 12·3 million in 1919 and 16 million in 1913. The French output for 1920 was 13·6 million tons, as against 2 million in 1917 and 21·6 million in 1913. China exported 672,150 tons in 1920, as against 304,349 tons in 1917.

Manganese;—World's Output of Manganese Ore.

1913, 2,272,000 tons; 1917, 1,864,000 tons.

Output of manganese ore varies in very close sympathy with that of iron ore. The output of manganese ore for the five years 1913 to 1917 inclusive averaged about 1·3 per cent. of the iron ore output, and it is noteworthy that this average was maintained in spite of the fact that Russian exports were cut off by the war.

Of the world's output for 1913, Russia contributed over 50 per cent., British India about 35 per cent., and Brazil about 5 per cent. Of the 1917 output, British India and Brazil together contributed about 60 per cent. Among noteworthy features are the discovery of the Gold Coast deposits, which yielded 35,189 tons in 1919; the increased production of the United States from 4,048 tons in 1913 to 305,869 tons in 1918, falling to 94,000 tons in 1920; and Brazil's increase from 120,335 tons (exported) in 1913 to 524,291 tons in 1917. The future of the Brazilian manganese industry is uncertain but its continued prosperity is a possibility to be reckoned with.

Nickel;—World's Output of Metallic Nickel.

1913, 32,000 tons; 1918, 47,500 tons.

During the war Canada increased its proportion of the world's output from nearly 70 per cent. in 1913 to nearly 90 per cent. in 1918, and large nickel refineries were established in the Dominion. The entire output of matte had previously been exported. Excessive production for war purposes resulted in heavy stocks after the armistice, and consequently in reduced output for 1919 and 1920. Until stocks are cleared, output is likely to be comparatively small.

Chromite;—World's Output of Chromite.

1913, 116,000 tons; 1918, 270,000 tons.

The increased war demand for chromite was met largely by the United States, where the output increased from 255 tons in 1913 to 82,350 tons in 1918, but fell to 3,900 tons in 1919, and practically ceased in 1920. Pre-war conditions as regards chromite are being rapidly restored, with Rhodesia and New Caledonia as the leading producers.

Tungsten;—World's Output of Tungsten Concentrates.

1913, 8,000 tons; 1918, 34,000 tons.

The importance of ferro-tungsten in the manufacture of high-speed tool steel compelled the United Kingdom, previously dependent on Germany for supplies of tungsten (manufactured largely from Burmese Wolfram), quickly to adapt itself to the war situation, and to manufacture all the tungsten and ferro-tungsten it required. Among other countries contributing to the world's increased production, the United States and China were conspicuous, the former increasing its output from 1,372 tons in 1913 to 5,486 tons in 1917, although producing only 295 tons in 1919. China produced 9,375 tons in 1918, as against 20 tons in 1914. Tungsten mining in the United States ceased during 1920, and is unlikely to compete in the near future with China.

Vanadium;—World's Output of Metallic Vanadium.

1913, 400 tons; 1917, 1,200 tons.

Increased supplies of vanadium during the war were obtained chiefly from the patronite deposits in Peru. The demand continued brisk until towards the end of 1920, but then abated, and the Vanadium Corporation of America closed its Colorado works, finding that the world's demand could be fully and most economically met by the Peruvian deposits.

Magnesite;—World's Output of Crude Magnesite.

1913, 595,000 tons; 1917, 668,000 tons.

An immediate effect of the war was to stop shipments to allied countries of sintered magnesia from Austria-Hungary, which had previously supplied the greater part of the world's requirements of refractory magnesia. British and French needs were met by the Grecian output, which had been in less demand for refractories before the war.

To meet its own requirements the United States increased its production of crude magnesite from 8,000 tons in 1913 to 282,891 tons in 1917, by developing new deposits in Washington State, which yielded nearly 132,000 tons in 1918. The output continued on a large scale during 1920, but having regard to competition with Austrian imports, it is doubtful whether this can be maintained, and the operating companies are demanding a high tariff on imports, although only about 20 per cent. of the magnesite consumed in 1920 was imported. It was recently stated that work on the Washington State deposits had been suspended.

Austrian exports for 1920 are reported as about 63,000 tons, a substantial improvement on the war period exports. In terms of crude (i.e., not calcined or sintered), this amounts to about 140,000 tons, as against 112,000 tons in 1917 and 445,000 tons in 1913 for Austria-Hungary.

Canada's output of magnesite increased from nil in 1913 to 57,143 tons in 1917, but fell to 8,875 tons in 1919, recovering to 16 400 tons in 1920.

Among other countries showing increased outputs, Italy is notable, with 590 tons in 1913, 30,571 tons in 1917, and 35,353 tons in 1919.

Graphite;—World's Production of Graphite.

1913, 134,000 tons; 1917, 213,000 tons.

During the war, there was an increased demand for graphite for crucibles, foundry uses and lubricants, and the world's output in 1917 was nearly 60 per cent. higher than in 1913. Of the countries participating in the increase, the most conspicuous were Germany, increasing her output of about 12,000 tons in 1913 to about 64,000 tons in 1918, and Madagascar, increasing from about 8,000 tons in 1913 to 35,000 tons in 1917. Ceylon, formerly the chief source of graphite has suffered through production in Madagascar, though even the Madagascar output has dropped heavily since the armistice.

The Utilisation of Exhaust Steam in Turbines.

By Maurice Deacon, M.Inst.C.E.

Twenty years ago the utilisation of exhaust steam in turbines was in its infancy. During this short period an enormous development of the use of exhaust and mixed-pressure steam turbines has taken place, particularly at collieries, where the volume of exhaust steam is necessarily large in relation to the horse-power developed, owing to the nature of the work to be performed; and it would now be difficult to find a modern colliery of any magnitude without one or more exhaust or mixed-pressure turbines in use.

Before the adaptation of the steam turbine to the use of exhaust and mixed-pressure steam, large volumes of steam were constantly being blown into the atmosphere at collieries, owing mainly to the inapplicability of condensing engines for the purpose of coal-winding.

The national economy in fuel which has been effected by the utilisation of exhaust steam cannot be accurately estimated, but it may safely be stated that hundreds of collieries in the United Kingdom are now performing the bulk, and, in many cases, the whole, of the underground pumping, hauling and electric lighting, through the medium of mixed pressure turbines.

As an example of the magnitude of this economy it may be fairly stated that a colliery of average depth (say, 500 yards) and raising from 2,000 tons to 3,000 tons of coal per day, will produce enough exhaust steam to develop at least 1,000 h.p., and that with the assistance of high-pressure steam when the supply of exhaust steam is insufficient, from 1,500 to 2,000 electrical horse-power may be produced through the medium of turbines and electric generators at such a colliery. Assuming as a rough estimate that there are 500 such collieries in the kingdom fully equipped with turbines, the total economy in fuel amounts to 2,000,000 tons or more per annum.

Fig. 1, on the next page, shows the general arrangement of a mixed-pressure turbine plant at one of the collieries under the author's control, from engine to generator. The exhaust steam is conveyed by the exhaust steam pipes A from the No. 1 winding engines and the fan engines to the receiver B, and thence to the accumulator C, the exhaust steam from the No. 2 winding engines being taken direct to the accumulator. From the accumulator it is conveyed by the pipes A 1 to the turbines D, which are direct coupled to the generators, and revolve at a speed of 3,000 r.p.m. High-pressure steam (for use when the exhaust steam is deficient) is admitted through the pipes E. After passing through the turbines the steam is carried to the condensers G.

The pressure of the exhaust steam generally given off from a winding or fan engine varies from 2 lb. to 3 lb. per square inch above the atmospheric pressure, which represents the pressure in the accumulator when not regenerating, and, together with a vacuum of 27 in. to 28 in., produces the required energy.

Fig. 2 shows the construction of the rotor and casing of a mixed-pressure turbine. Fig. 3 shows the construction of an accumulator. The exhaust steam passes through the horizontal pipe A and the branch

MIXED-PRESSURE TURBINE PLANT FOR USING EXHAUST STEAM.

Fig. 1.

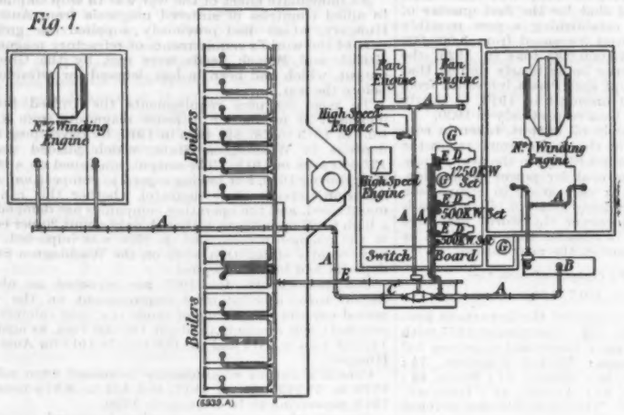


Fig. 2.

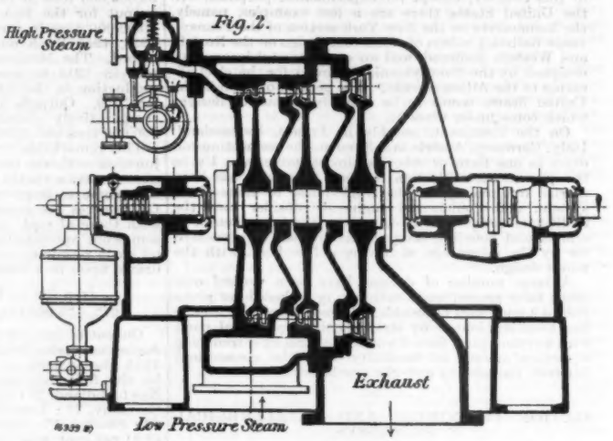
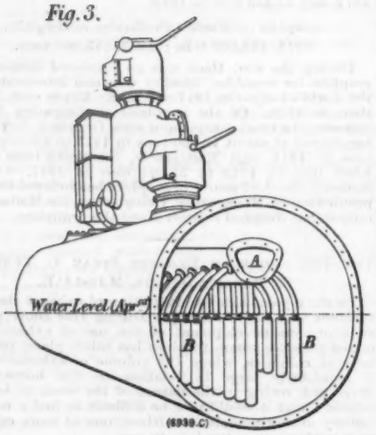


Fig. 3.



pipes B, by which the water in the accumulator is heated to the temperature of the exhaust steam. The exhaust steam from several engines may be introduced into the accumulator, and owing to the intermittent operation of winding engines, the more constant-running engines there are which can contribute a constant supply of steam the better, in order that, if the winding engine is stopped for several minutes, as is sometimes necessary, the period of stoppage is bridged over by the evaporation of the water in the accumulator.

The cost of generating electrical power by exhaust steam is naturally very low, having regard to the fact that the steam would otherwise be wasted.

Disregarding the exhaust steam as of any value, the cost of running is confined to labour, repairs, stores, and interest on capital and depreciation of plant. Taking the two latter at 20 per cent. on the capital outlay the cost of production per B.Th.U. with exhaust steam only is approximately 0·20*d.*, and with mixed-pressure consisting of 20 per cent. of high-pressure steam 0·40*d.* These costs are based upon plants at collieries controlled by the author, and are taken upon the present-day values of plant, wages and stores, and with small coal at 20*s.* per ton with the plant running 10 hours per day. On 20 hours per day instead of 10, on approximately full load, the cost per unit would have been 0·10*d.* for exhaust steam, and 0·20*d.* for mixed pressure steam. Prior to the war the cost was rather less than half the present-day cost.

The steam consumption in turbines varies according to the load. The following tables show the approximate steam consumptions for 1,500-kw., 2,000-kw. and 3,000-kw. turbines, with high-pressure steam and with exhaust steam :—

High-Pressure Steam.

Steam pressure 175 lb. per square inch. Superheat, 150 deg. F. Vacuum, 28½ in.

—	1,500 Kw.	2,000 Kw.	3,000 Kw.
	lbs. per kw.-hour.	lbs. per kw.-hour.	lbs. per kw.-hour.
Full load	13·50	13·10	12·68
Three-quarter load ..	13·85	13·55	13·08
Half load	14·75	14·50	13·88

Exhaust Steam (Mixed-Pressure Set).

—	1,500 Kw.	2,000 Kw.
	lbs. per kw.-hour	lbs. per kw.-hour
Full load	29·25	28·95
Three-quarter load	30·20	29·85
Half load	32·75	32·40

The above steam consumptions include all losses in the turbine and generator.

STEAM VERSUS ELECTRIC WINDING.

By WILLIAM CHARLES MOUNTAIN.

THE subject of this paper is one in which I took considerable interest and have already dealt with in papers read in 1906 before the Institution of Electrical Engineers, and also in the same year before the Institution of Mining Engineers, and before writing these papers I visited Germany in order to see exactly what was being done there, and what I considered the future of electric winding in this country would be. My investigations were at that date based upon the value of coal used under the boilers—namely, 1*s.* 6*d.* up to 6*s.* 3*d.* per ton, or an average price of, say, 3*s.* to 4*s.* per ton, and as the price of small coal to-day is quite fictitious, and it is difficult to say what the market price may be in the near future, any details as to costs of winding into which coal enters must necessarily be very approximate.

Whether it is economical to adopt steam or electric winding depends upon so many circumstances that it is quite impossible to lay down any hard and fast rules, for the following reasons :—

1. If the colliery, or collieries, are so isolated that a supply of electricity cannot be obtained from a public power station, and the collieries are of large capacity, such as we have in Yorkshire, Nottinghamshire and in South Wales, and also to some extent in Lanchashire, then I think there is no doubt that the most economical method to adopt is to put down steam winding engines and to utilise the exhaust steam in mixed-pressure turbo-generators.

2. If the collieries are of moderate size, or are small collieries, and there are several of them under one or more ownerships, then it is possible, and in fact probable, that electric winding can be economically adopted, particularly if power can be obtained from a power company at a reasonable cost, but even under these circumstances the type of winder to be adopted must be carefully conaidered, because unless the power company has a large capacity it may be necessary to adopt electric winders with Ilgner balancers, as small direct-driven or geared winders with three-phase motors with rheostatic control may throw a peak load on the power station which would cause serious trouble.

3. There are also collieries where they may have blast furnace or coke-oven gas available, and this could be used either in gas engines or under boilers, and there is no doubt that in simplicity and first cost the use of steam turbines, with water tube boilers using gas as fuel and properly arranged for superheaters, has advantages, and that a very high degree of economy can be obtained.

4. On the other hand, circumstances may make it possible to utilise the gas direct in gas engines, but it all comes to a question of cost and efficiency in running, also freedom from stoppages due to breakdowns or repairs that may be necessary in daily working.

As an example of heavy winding in collieries in Derbyshire, which may be taken as typical of the heavy duty in this country, I may mention two collieries which I will call "A" and "B" The depths are respectively 820 yards and 900 yards, and the total weight of coal wound per wind 9 tons and 6 cwt., the further particulars in each case being as follows :—

Time of wind	60 seconds.
Time of changing	12 seconds.
Steam pressure at boilers ...	160 lb.
Diam. of steam engine cylinders	44 in.
Length of stroke	84 in.
Dimensions of conical drum ...	17–32 ft.
Estimated horse-power on—	
Second revolution	3,960
Fourth revolution	3,680
Sixth revolution	4,380
Seventh revolution	1,780
Steam consumption per wind exclusive of condensation in pipes, &c.	600 lb.
Steam consumption per shaft horse-power	30
Consumption of coal assuming 50 winds per hour per winding day of 13 hours 20 minutes...	22 tons 5 cwt.
Cost of winding engines to-day approximately	20,000*l.*

The exhaust steam from these winding engines is used in mixed pressure turbo-generators, and I am informed that in 1918 the costs per unit delivered to the busbars in the power station were as follows —

—	Labour, Steam and Stores.	15 per Cent. Interest and Depreciation on Capital.	Total Cost.
	per kw. *d.*	per kw. *d.*	per kw. *d.*
Exhaust steam only ..	0·0189	0·06	0·0789
Mixed pressure steam ..	0·0902	0·06	0·1502
High pressure steam ..	0·227	0·06	0·387

In the case of the high-pressure steam the coal to the boilers was taken at 7*s.* per ton.

Messrs. Robey and Co., of Lincoln, have given me further examples of large steam winding engines supplied to a South Wales Colliery, with two high-pressure cylinders 31 in. diameter, two low-pressure cylinders 52 in. diameter by 72 in. stroke, with semi-conical drum 14 ft. to 22 ft. The shaft horse-power is estimated at 800, whereas the maximum indicated peak horse-power is 4,300.

Messrs. Fraser and Chalmers have also given me particulars of winding engines of the double-cylinder type, 36-in. diameter by 72-in. stroke, in which they estimate the steam consumption per shaft horse-power at 33 lb. Also of cross-compound engines with cylinders 32 in. by 53 in. by 66 in. stroke, in which they estimate the steam consumption per shaft horse-power at 33·6 lb.

These examples will show that up-to-date modern steam winders are economical as regards the consumption of steam per shaft horse-power, and it must be remembered that in utilising exhaust in exhaust steam turbines a kilowatt can be obtained for about 35 lb. of exhaust steam at 16 lb. pressure absolute delivered from the winding engines into the turbines.

Electric winding has made very substantial progress, and a great deal of heavy work of this description has been done by the British Westinghouse Company, now Messrs. Metropolitan-Vickers Electrical Company, in South Africa. The winders are fitted with semi-conical or parallel drums in accordance with the requirements, and from information supplied to me the motors are rated to give from 1,450 h.p. to 1,600 h.p. normally, but are capable of carrying a peak load of from 3,000 h.p. to 4,000 h.p.

A successful electric winder has been installed by Mr. Bramwell at the Great Western Collieries, South Wales. Messrs. Siemens (now the English Electric Company) have also successfully applied electric winding to mines in South Wales, the North of England, and elsewhere.

To reduce the whole matter to a simple basis I cannot do better than repeat what I stated in summing up my views in 1906, namely :—

(a) For small collieries there is a future for electric

winding if the coal used under the boilers is of any considerable value.

(b) In large collieries there is a future for electric winding if the coal used under the boilers exceeds 8s. to 10s. per ton, but this, of course, depends entirely upon the relative costs of steam winders with their boilers compared with the electrical equipment.

(c) Electric winding cannot be economically applied to collieries for very large outputs where it is necessary to install a generating plant to produce the necessary output for operating the winder, because the horse-power required for winding is so greatly in excess of the horse-power required for driving other machinery, and as it would be necessary to provide a stand-by plant, the costs would be prohibitive.

(d) In collieries generally, particularly those in which electric winding is adopted, colliery owners would be well advised to take their current from the supply companies, assuming they can purchase it at a reasonable price, even if this price is slightly in excess of the cost at which they can produce the current themselves, due to the amount of capital required for the generating plant being so heavy. The same capital expenditure could be applied to much greater advantage in increasing the electrical plant on the surface and underground.

The Relative Values of Protective Metallic Coatings for Iron and Steel.

By Sherard Osborn Cowper-Coles, Assoc.M.Inst.C.E.

The protection of iron and steel from corrosion by means of protective metallic coatings can be divided under two headings: (1) Electro-positive metallic coatings; (2) electro-negative metallic coatings.

A large number of engineers do not appreciate the great difference between the two coatings, with the result that much money is wasted and in many cases great risks run. Electro-positive metallic coatings are those which are electro-positive to the underlying iron and steel, such as zinc, aluminium and brass. Electro-negative metallic coatings are those which are electro-negative to the iron or steel, such as lead, tin, copper and nickel. The latter are only protective as long as the coatings remain intact; once penetrated, corrosion takes place more rapidly than if there was no coating, hence the danger of coating iron and steel with a negative protective coating, for instance, steel wire with lead as the coating remains intact, whilst corrosion goes on beneath the covering metal. It is proposed, therefore, to limit these notes to the discussion of the relative value of electro-positive coatings, which are the only protective metallic coatings of commercial value. The reason why zinc is the metal most extensively used, is that it is electro-positive to iron and steel. It is therefore proposed to discuss its relative advantages and disadvantages first.

Zinc coatings can be applied by four methods: (1) Dipping in molten zinc; (2) Sherardising; (3) electro-zincing; (4) spraying.

Dipping in Molten Zinc.—This process is used for a variety of work, and is the only process at present successfully employed for tank work and corrugated sheets, in the first instance, for the reason that it is the only process that solders or makes watertight joints, and in the second instance, it is the only process that enables sheets to be rapidly coated by a continuous process.

The chief advantages of the hot or dipping process are: (1) Its soldering action or rendering made up articles watertight; (2) its rapidity; (3) it ensures a considerable thickness of zinc, except in the case of sheets or wire, which can have most of the coating wiped off, leaving a mere film.

The chief drawbacks to the hot galvanising process are: (1) The coating is not alloyed or amalgamated with the surface; (2) it can only be worked economically on a large scale, and continuously; (3) the waste of zinc is considerable; (4) the flux employed, sal ammoniac, is expensive and helps to start corrosion; (5) paint does not adhere well.

The spangled effect given to hot galvanised sheets, instead of being an advantage from a protective point of view, is a drawback, and some engineers who have studied the subject now specify that galvanised iron sheets should not be spangled. The spangles are sometimes obtained by the addition of a small quantity of tin, which is not advantageous. If a section is made through a spangle, it will be found that the zinc is very much thinner in some parts than others.

Sherardising or Vapour Galvanising.—This process consists of placing the iron or steel in zinc dust or powder, a by-product from zinc smelting works, in a closed drum or receptacle, and heating for several hours at a temperature of several hundred degrees below that employed for the molten zinc process.

The chief advantages are: (1) The zinc coating is quite evenly distributed, so that screwed or machined parts can be zinc coated; (2) the zinc amalgamates with the surface; (3) the temperature employed is lower than that required for the molten process; (4) the surface forms an excellent surface for painting on; (5) the working costs are less and it can be worked intermittently.

The chief drawbacks are: (1) There is no soldering action, and it cannot be used for making vessels watertight; (2) a thin and inefficient coating can be supplied if too low a temperature is employed.

Electro-Zincing.—This process consists of placing the iron and steel to be coated with zinc in tanks, containing zinc solution such as zinc sulphate, connecting the iron or steel to be zinced to the negative pole of a dynamo and zinc sheet or slab with the positive.

The chief advantages of the process are: (1) It can be carried out in the cold; (2) large objects can be coated.

The chief drawbacks are: (1) The zinc coating is uneven, building up on protruding parts, hollow parts receiving very little zinc; (2) if not carried out under very careful supervision, the thickness of the zinc may be a mere film.

Spraying Process.—This process consists of spraying molten zinc on to the surface by means of a.r, or a reducing or inert gas, and has the advantage that it can be applied to iron and steel structure when erected, but the process is very costly and the coating porous.

Considering the great importance of the effective protection of iron and steel from corrosion and the vast sums of money spent yearly on the upkeep of iron structures and renewals of all sorts due to corrosion, it is astonishing that more attention has not been given to the matter. It offers a most useful field of investigation and might well be carried on with the researches now being made in connection with the corrosion of condenser tubes.

There are no means at present of determining in a practical manner the thickness of zinc or zinc-coated surfaces. The copper sulphate test, dipping in a saturated solution of copper sulphate, although still specified by many engineers and Government departments, is quite useless for zinc coatings applied by electro-zincing or Sherardising. It therefore appears that the first investigation should be to devise a standard workshop test for determining the thickness of the zinc coatings, and then apply the corrosion and durability tests. Many tests have been made which are of little or no value, for the reason that the thickness of the zinc coatings have not been determined in a manner that could be applied in everyday commercial practice. An electro-zinced surface might have a film of zinc evenly distributed, whilst a hot galvanised surface might have five times the amount and be very unevenly distributed, so a common test without a previous practical test to determine the thickness and even distribution of the zinc coating is of little value.

It is hoped these few remarks may lead to a useful discussion, the subject receive the attention it deserves, and some systematic research work be organised.

SECTION V.—SHIPBUILDING.

Notes in Connection with Experience with Marine Turbine Reduction Gears.

By R. J. Walker, C.B.E., and S. S. Cook, B.A.

Mechanical gearing in association with steam turbines was tried experimentally in the cargo steamer Vespasian in 1909, in order to widen the field of operation of the turbine by its application to vessels of moderate and slow speeds. Up to this period the adoption of the direct-coupled turbine, owing to considerations of economy, weight and first cost, was not found to be universally practicable for vessels having a lower speed than about 18 knots. A few vessels, however, with speeds ranging from 15 knots to 18 knots were fitted with direct-coupled turbines, but the steam economy was found to be inferior to the best reciprocating engine practice.

For slow-speed vessels in a few instances commencing in 1908 a combination of reciprocating engines, working in conjunction with low-pressure turbines, was adopted, the reciprocating engine driving a propeller shaft and exhausting into the turbine, which was directly coupled to another propeller shaft. By this arrangement an additional economy of 12 per cent. to 14 per cent. was obtained as compared with quadruple engines.

The success of the experiments carried out in the Vespasian led very quickly to the application of mechanical gearing for all classes of vessels, from the lowest to the highest powers and speeds. In 1910 the Admiralty placed an order for two torpedo-boat destroyers—H.M.S. Badger and Beaver—in which the high-pressure turbines were geared, the low-pressure turbines being directly coupled to the propeller shafting, and in 1912 two further torpedo boat destroyers—H.M.S. Leonidas and Lucifer—of 22,500 s.h.p., were ordered in which gearing was adopted for the transmission of the whole of the propelling power. These vessels were the forerunners of a long list of successful installations of this type for naval work, until at the time of the armistice the total horse-power of geared turbines completed and under construction for war vessels for Great Britain and her allies was about 16,000,000. An account of the experience with these installations in the British warships was given by Commander Tostevin, in a paper read before the Institution of Naval Architects in 1920, in which he stated that out of 556 geared vessels which had been on service (representing 6,794,000 s.h.p.) there were only three cases where it had been necessary to refit for misalignment, two in which undue noise developed, two cases of fractured teeth, and one breakdown due to a ¾-in. bolt passing between pinion and wheel.

In the Mercantile Marine geared turbines were adopted in 1911 for two new cross-Channel steamers of the London and South-Western Railway Company, Normannia and Hantonia, whilst for cargo vessels geared turbines were first applied in 1913 to the S.S. Cairnross built for Messrs. Cairns, Noble and Co. The success of these vessels was quickly recognised by other shipowners, with the result that by the end of 1914 there was a total of over 260,000 h.p. of geared turbines for mercantile service built or under construction.

In all the installations referred to above the gears were of the single-reduction type, the largest ratio of reduction that had been adopted being 26 to 1 in the case of the S.S. Cairnross. On the outbreak of war, designs were in hand for gearing by double reduction so as to obtain higher ratios between revolutions of turbine and propellers without excessive size of gear wheel, or excessively small diameter of pinion, the speeds of revolution of the turbines and propellers being maintained at their speeds for maximum efficiency.

Since the outbreak of war about 800 ships, representing a total horse-power of over 2,000,000, have been constructed in America with double-reduction gearing. In Great Britain and other countries the number built and under construction is about 220, representing a total power of 1,500,000 s.h.p.

In the earlier mercantile vessels, with direct-coupled turbines, of the cross-Channel type, with speeds of over 20 knots, the steam consumption of the turbines was from 15 lb. to 16 lb. per shaft horse-power, and in vessels of large size and power this was reduced to about 12 lb. per shaft horse-power. Whereas at the present day in vessels of moderate size and power with single-reduction gearing a steam consumption of 11 lb. per shaft horse-power can be obtained with saturated steam, and under 9 lb. per shaft horse-power with superheat of 200 deg. F., with double reduction gearing a steam consumption can be obtained of about 10 lb. per shaft horse-power saturated steam, and about 8 lb. per shaft horse-power with superheat of 200 deg. F.

In large-powered warships with four shafts and single-reduction geared turbines and additional cruising turbines a very flat curve of steam consumption is now obtained ranging from 10 lb. per shaft horse-power at full power to 12½ lb. at one-tenth of full power. The steam consumption of the earlier direct-coupled turbines fitted with an additional stage for cruising was about 12 lb. at full power and 24 lb. at one-tenth full power.

In mercantile vessels of lower speeds and power very careful comparisons have been made between geared turbines and reciprocating engines. In a paper read before the North-East Coast Institution of Engineers and Shipbuilders in December, 1919, details, furnished by shipowners, of comparative results of various vessels were given. The average saving of fuel in vessels fitted with geared turbines was shown to be more than 20 per cent. over that of vessels fitted with reciprocating engines.

The gear-wheel teeth are of the involute type generated in the majority of cases by the hobbing process. The pitch of the teeth is small, usually $\frac{7}{10}$-in. for the first reduction, and 1 in. for the second reduction. These are the pitches measured normally to the teeth, which are cut spirally. In order to obtain as silent running as possible the earlier gears had a spiral angle of 45 deg., but 30 deg. is the angle now commonly adopted, and gives a longer line of contact on the teeth and facilitates machining. The efficiency of such gears is very high—about 98½ per cent. for single reduction, and over 97 per cent. for double reduction; the high-speed bearings of the pinions absorb the greater part of the losses represented by these figures.

Recent experiments upon the strength of teeth have shown that they have an enormous factor of safety for bending. With an experimental pinion of 6 in. diameter and gear wheel of 26 in. diameter having teeth of $\frac{7}{10}$-in. pitch at spiral angles of 30 deg. under static loading, it required a tangential load of more than 40,000 lb. per in. of face to break the teeth, so that there is ample security against accidental shock.

As regards tooth pressure the load per inch of face should be judged in its relation to the diameter of the pinion employed. The following figures represent the general average practice for service conditions in British merchant ships. For pinions less than 10 in. and with the normal depth of tooth, the value of the constant $\frac{P}{d}$ lies between 60 and 75; for pinions above 10 in. diameter the value of the constant $P\sqrt{d}$ lies between 180 and 220, unless lower values are specially requested.

In America a good many troubles arose in connection with mercantile vessels built there and fitted with double reduction gearing, the percentage being fairly considerable, due to a combination of circumstances existing under war conditions. In this country there have been very few cases of trouble, and the percentage of such cases is remarkably small. The troubles which have been experienced have been traced, with one exception, to defective design or material, faulty workmanship, inferior lubrication, or temporary stoppage of oil when running, but as the result of experience in both America and this country there is nothing to fear for the future success of double-reduction gearing.

The exception referred to arose in connection with two oil-carrying steamers, the San Florentino and San Fernando, in which the machinery is placed right aft. After the trials of the latter, indications were observed of excessive pressure at definite angular positions around the gear wheel. A peculiar condition had apparently arisen due to the variation in the propeller resistance as the blades cut through different parts of the wake, and the irregular tooth pressure which this caused was aggravated by the fact that at the full normal working speed the period of the blades passing the stern-post nearly synchronised with the period of the torsional vibration of the propeller and shaft in relation to the gear, thus greatly augmenting the pressure on the main gear wheel at certain positions on the periphery.

Careful investigations were made, an account of which appears in a paper read by the authors before the Institution of Naval Architects in March last. The obvious remedy appeared to be to keep away from this critical period, and in the case of the S.S. San Florentino, a three-bladed propeller was fitted instead of the existing four-bladed one, and this had the effect of diminishing the frequency of the blades passing the stern-post by about 30 per cent. Concurrently new rims were fitted to the secondary gear wheels cut with a deeper tooth, so as to obtain increased tooth surface. It is understood that the gearing in this ship, after running 3,000 miles, is in splendid condition.

In the San Fernando temporary measures only were taken to obviate the synchronism to which the authors have alluded, by increasing the pitch of the propeller blades from 18 ft. 6 in. to 20 ft. 6 in., and thus slightly reducing the revolutions, the gears in this vessel remaining

RECENT PROGRESS IN LARGE DIESEL ENGINES FOR THE MERCANTILE MARINE.

LIST OF IMPORTANT DIESEL SHIPS IN SERVICE AND BUILDING GIVING PARTICULARS OF THEIR MACHINERY.

Date.	Name of Vessel.	Makers of Machinery.	Type of Engine.	Cycle.	I.H.P. of Engine.	B.H.P. of Engine.	No. of Cylinder	B.H.P. per Cylinder.	Diameter of Cylinder in In.	Stroke, In.	Ratio Stroke to Bore.	R.P.M.	Piston Speed. Ft. per Min.	M.E.P. on B.H.P. Basis.	M.I.P. on I.H.P. Basis.	Consumption of Fuel Lb. per Sq. In. Piston Area.
1912*	Juno ..	Werkspoor	Werkspoor ..	4 single-act.	1,460	1,100	6	183	21½	39½	1·87	125	820	84·0	111·0	0·219
1919*	Glenapp ..	Harland and Wolff ..	Burmeister and Wain	4 single-act.	3,200	2,625	8	328	29½	43 5/16	1·46	115	830	76·0	93·0	0·202
1920*	Afrika ..	Burmeister and Wain	Burmeister and Wain	4 single-act.	2,250	1,700	6	283	29½	45½	1·55	115	865	65·0	86·0	0·179
1920*	Glenogle ..	Harland and Wolff ..	Burmeister and Wain	4 single-act.	3,200	2,625	8	328	29½	45½	1·55	115	865	75·0	91·5	0·206
1920*	Cubore ..	Bethlehem Steel Co.	Bethlehem ..	2 single-act.	3,900	2,700	6	450	25½	48	1·87	100	800	73·0	105·0	0·39
1920*	Ansaldo San Giorgio III	Ansaldo San Giorgio	Ansaldo.. ..	2 single-act.	1,600	1,200	4	300	24 3/4	35 7/16	1·43	110	650	63·0	84·0	0·272
1920*	Fullagar ..	Cammell Laird ..	Fullagar ..	2 opposed p.	660	500	4	125	14	20	1·43	110	367	73·5	97·0	0·179
1920*	Fritz ..	Blohm and Voss ..	M.A.N.	2 double-act.	1,250	850	3	283	18¾	28	1·48	110	515	65·0	93·5	0·223
1920	—	Swan Hunter and Wigham Richardson	Polar	2 single-act.	1,500	1,130	6	188	18	37	2·06	115	710	69·0	92·0	0·325
1921	—	Gotaverken	Burmeister and Wain	4 single-act.	1,600	1,200	6	200	25	51	2·04	95	805	67·0	89·5	0·171
1921	Domala ..	N.B. Diesel Co. ..	N.B. Diesel ..	4 single-act.	2,330	2,000	8	250	26½	47	1·77	96	750	79·5†	92·0	0·191
1921*	Sardinia ..	Werkspoor	Werkspoor ..	4 single-act.	2,140	1,600	6	266	26¾	47½	1·79	100	788	82·0	110·0	0·204
1921*	Seminole ..	Vickers, Ltd. ..	Vickers	4 single-act.	1,620	1,250	6	208	24½	39	1·59	118	767	76·0	99·0	0·185
1921	Pinzon ..	Beardmore and Co...	Beardmore-Tosi	4 single-act.	1,600	1,200	6	200	24½	38¾	1·57	120	767	74·0	98·0	0·180
1921	—	Stephen and Sons ..	Sulzer	2 single-act.	2,200	1,650	4	412	26½	43 3/16	1·62	85	610	78·0	108·0	0·321
1921	—	Denny Brothers ..	Sulzer	2 single-act.	1,700	1,250	4	312	23½	37	1·56	100	615	76·0	103·0	0·314
1921	—	Cammell Laird ..	Fullagar ..	2 opposed p.	1,580	1,200	4	300	18½	25	1·35	115	480	77·0	101·0	0·248
1921	Yngaren ..	Doxford	Doxford ..	2 opposed p.	3,000	2,700	4	675	22 3/4	45½	2·0	77	585	93·0	103·0	0·362
1921	Suphenco ..	James Craig Engine Works, U.S.A.	Craig	4 single-act.	2,240	1,850	6	308	30	48	1·6	105	840	68·5	82·0	0·183

* In operation at sea. † No compressors on main engine.

as originally designed. An inspection of the gears after running 50,000 miles showed the teeth to be in excellent condition, no wear whatever having taken place other than the slight pitting or flaking which occurs in many gears in the initial running and then ceases. This result was achieved with only the slight alteration in the pitch of the four-bladed propeller referred to.

Several vessels with double-reduction gearing are now on service, giving very satisfactory results. The S.S. Somerset has been in service for over two years, the S.S. San Florentino and S.S. San Fernando over eighteen months, and three of the "N 1" class standard ships—the Danier, Andalusia and the Aster—for over twelve months. The loads and load constants for these vessels on service conditions are as follows:—

Ship.	Second Reduction Pinion Diameter.	Load Pin in Lb. per Lineal In. of Face.	$P\sqrt{d}$.
	d.		
S.S. Somerset	22·7	928	195·0
S.S. San Florentino ..	19·334	932	212·5
S.S. San Fernando			
S.S. Danier	13·58	880	238·0
S.S. Andalusier			
S.S. Aster			

The authors' experience has led them to the conclusion that the loads adopted are still a long way from the maximum which may be safely employed if the teeth are accurately cut. The cause for any failures of gear teeth with loads hitherto adopted is not to be found in tooth pressure, but in want of accuracy of the teeth. The effect of want of accuracy is two-fold. It subjects the teeth to shock due to the sudden changes of speed enforced upon heavy moving parts, and it also leads to imperfect rolling of the tooth surfaces and a consequent localisation of the pressure. Accuracy is, in the authors' opinion, the factor of greatest importance, and no effort should be spared towards the highest perfection of gear-cutting machinery and methods.

RECENT PROGRESS IN LARGE DIESEL ENGINES FOR THE MERCANTILE MARINE.

By JAMES RICHARDSON, B.Sc., Assoc.M.Inst.C.E.

PRIOR to the war, with the exception of a few four-stroke cycle engines of relatively small power, little real progress was made in the application of Diesel engines to ships in the mercantile marine.

During the years 1914–19, however, a steady and consistent policy of development took place, naturally, under the circumstances, mainly confined to neutral countries. The four-stroke cycle single-acting, crosshead type of engine, with forced lubrication, went through a process of gradual evolution. There was no radical changes either in thermodynamical theory, in practical application, or in the metals and materials used; the efficiency, moreover, remained almost constant. With increasing power and growing experience, the cylinder mean effective pressure considered desirable for continuous running was gradually reduced from 85 lb. to 75 lb. per square inch on a brake horse-power basis. A number of ships were engined with two-stroke cycle Diesel machinery, but the progress made was less definite and less convincing.

From 1912 to the present time, the horse-power per single cylinder has risen by small steps from little more than 100 b.h.p. to over 300 b.h.p., and, with multiplication of cylinders, a maximum power of approximately 4,800 b.h.p. (with 16 cylinders on twin screws) per ship can be obtained with machinery of proved design.

Since the war, conditions the world over, in all spheres of activity, have been unique. Difficulties with all classes of labour ashore and afloat, increased transporting tonnage now available for liquid fuels, and the recent substantial fall in price, have compelled attention to the subject of the substitution of oil for coal. The economic advances, under present conditions, of the liquid over the solid combustible for power generation, have been quickly and generally realised.

The Diesel oil engine utilises oil fuel with an economy far exceeding that of all other prime movers, and the total savings due to the adoption of the principle of internal combustion are even greater than is solely consequent upon the much lower consumption of fuel of from one-third to one-fifth of that required for equally powered steamers, since, apart from fuel costs, there are a number of other important gains.

All shipowners are now, at least, giving close attention to the merits of this system of propulsion, and construction is advancing. The gross tonnage of ships to be equipped with Diesel machinery launched in 1913 was 60,000 tons. In 1919 the figure was 85,000, in 1920, 189,977, whereas building last year there were 454,502 tons of Diesel-driven ships, or over 7 per cent. of the world's total under construction. In the light of the past ten years experience, the statement will not be denied that the Diesel engine has proved an efficient, reliable and thoroughly seaworthy prime mover, suitable for a large proportion of the total sea-borne tonnage. In 1920, of 364 ships launched of more than 2,000 gross tons each, 350, or 96 per cent. of the total number, required less than 5,500 i.h.p. of machinery per ship. In numbers 96 per cent., and in tonnage 88 per cent., come thus within the scope of the oil engine, so far as total horse-power is concerned.

The principles underlying the operation of internal-combustion machinery are now becoming more widely understood, at least so far as the simple applications are concerned, making easier the path of the advocate of this form of prime mover.

The technical pride of the engineer, and the desire on the part of the shipowner for greater economy with the larger type of ships, such as intermediate liners, will not allow the problem to remain long unsolved for powers higher than 4,800 b.h.p. per ship. In the near future the maximum power with oil engines will increase. This problem is being attacked in this country, and the large variety of types under construction here indicates an enterprising and progressive policy of determined trial, in contrast with the apathy with which British engineers were charged before the war.

The rival claims of some of these various systems indicated in the table have yet to be fully sifted in the light of practical sea-going experience. It is most probable, however, that a considerable time will elapse before development and increased application will enable a substantially higher plane of performance and efficiency to be reached, when the issue between the various types will become narrowed down. It is hoped that the results of sea-going experience will be freely disseminated and that the policy of secrecy, which is to be condemned and which, at least in its initial stages, particularly characterised this movement, will not be pursued. The power which various types of engines can consistently and continuously sustain at sea is more particularly a point in question, about which little information can generally be gleaned.

The maximum power which can be obtained from a given cylinder depends primarily on the limits of heat transfer from the working fluid through the metal surrounding the combustion space to the cooling medium. Attention is directed to the last column in the table indicating this quantity conveniently expressed in terms of pounds of fuel per square inch of piston area, showing the divergence in published ratings in this respect, although it is suggested by the author that the results in practice, so far, do not differ so widely, and that the quality and rate of heat transfer continuously and successfully achieved, are much nearer the lower than the higher figure. The application of metallurgical research and improved methods of construction are the paths being traversed towards the higher results desired.

Another basis of comparison concerns the qualities of fuel which various types of engines can consume economically in respect of the amount of attention to be given to the running parts. The types of fuel oils now running on the market are showing a tendency to deteriorate in quality, increasing in viscosity, and decreasing in calorific value, so that the engine designer, constructor and operator must continue to study their efficient utilisation.

Various designs and types of engines, whether working on the two or four-stroke cycle principle, single or double-acting, or utilising one or other of the alternative systems of fuel feeding, will, therefore, be judged largely on the capacity to burn satisfactorily and economically various qualities of oil fuel, including lower grade oils, with minimum attention and upkeep costs on a basis of horse-power continuously developed at sea.

SECTION VI.—WATERWORKS, SEWERAGE AND GASWORKS.

PIPES FOR PRESSURE CONDUITS.

By FREDERIC WILLIAM MACAULAY, M.Inst.C.E.

IRON, in the form of cast-iron or steel, hitherto almost the sole material used for the construction of conduits for conveying water under pressure, has of recent years proved unsatisfactory, particularly for the conveyance of the, generally, ferruginous waters from upland gathering grounds. This is shown in the comparatively rapid diminution in the carrying capacity of such conduits through internal nodular corrosion and deposits of a slimy nature. The nodules consist very largely of ferric and ferrous oxides, and originate, apparently, from the action of CO_2 in the water on the metal, through evidently unavoidable imperfections in all forms of bituminous coating. Possibly also bacterial action contributes to their formation. The presence of masses of iron oxides in the pipes cannot but be favourable to the growth of the iron bacteria present in all ferruginous waters which cause the slimy deposits. Lime treatment and de-aëration have been tried to prevent incrustation, sand filtration to prevent the entry of iron bacteria to the conduits. These attempts have proved costly and by no means successful. Deterioration of discharging capacity of cast-iron and steel mains has recently been measured to the extent of 25 per cent. in fifteen years, in Birmingham's 42-in. mains (with roughing filters at their head), of 25 per cent. in eight years in Liverpool's 42½-in. mains, and of 40 per cent. in twenty years in Manchester's 44-in. mains, and so forth. The only practicable palliative is periodical scraping or brushing out of the mains. This is more or less costly—according to circumstances—possibly destructive, and the relief given is exceedingly transitory, since deterioration at once starts again and proceeds, at least, as rapidly as before, if not more so. Allowance for this deterioration has to be made in the original diameter of an iron main and for the destructive effect of oxidation on the metal in the thickness of the pipes. There are, therefore, elements which detract from the economical use of iron—at any rate, as manufactured to-day—for this purpose.

Long observation has shown that good cement concrete surfaces in contact with normal upland waters do not suffer any deterioration thereby; that there is no destruction, no nodular or other incrustation, and but little slimy or other deposit. Further, it has been proved beyond doubt that one certain way to preserve iron or steel is to embed it wholly in cement concrete.

It should not be beyond the ingenuity of engineers so to embed steel in a protective body of cement concrete as to form a watertight conduit capable of resisting considerable internal and external stresses. The elements making for economy in this form of construction are: That the main can be made, at the outset, of practically the net diameter required, that is, without, say, more than 5 per cent. allowance for incrustation; that only just the quantity of metal necessary to withstand internal working pressures need be used—no allowance against corrosion or for stiffness need be added—whilst absolute protection of the metal and the necessary stiffness is provided by the concrete at a cost which should not exceed that of the metal saved as compared with a whole-metal main. Indeed, some excess of such cost would be justified by the provision of a conduit with a practically constant capacity. With very little care the coefficient of rugosity can be made in a concrete main, at the outset, almost as low as that of a new metal main. Lastly, there appears no reason why the "life" of a good reinforced-concrete main should not exceed that of a metal, or, indeed, equal that of an ordinary concrete non-pressure conduit.

The following is a list of some reinforced-concrete mains in this country which have all, it is understood, so far justified the above statements:—

	Date of Laying.	Use of Main.	Diameter.	Working Pressure.
			in.	ft.
Swansea ..	1905–6	Water	20	246
Norwich ..	1908	Sewage	36	131
Swansea ..	1910	Water	24	500
Clydebank ..	1910	Water	18	390
Birmingham ..	1921	Water	60	255

The above are all of one type. They have a continuous steel tube, mainly for watertightness, between and supported by helical internal and external steel members—in the latter of which lies the true strength of the pipe—the whole embedded in concrete which is purely protective and has a thickness, in the largest pipes, of 3½ in. to 4½ in. The joints are decidedly rigid.

Of late years there has come to the front a new form of reinforced concrete pipe, in which steel wire reinforcement is embedded in a centrifugally-made concrete cylinder. The concrete, which is of remarkable density, is depended upon for watertightness. This form of pipe may be used in large diameters up to working pressures of 230 ft. For higher pressures steel cylinders lined internally—preferably by centrifugal process—with lightly reinforced concrete may be used, external protection being given by bituminous or, in bad ground, concrete coating. In this, again, the cylinder may be just thick enough to withstand internal working pressures, the requisite protection and stiffness being afforded by the concrete. Alternatively to steel, the cylinder may perhaps be made, when the manufacture of it has been developed, of centrifugally-cast iron, which possesses far greater tensile strength than ordinary cast-iron and is apparently free from the frailties to which the latter is so liable, and to protect against which empirical additions to the theoretical thickness of this metal must always be made. This form of pipe lends itself to a more flexible and probably cheaper type of joint than the first-mentioned.

For reinforced concrete pipes, run lead joints may not be practicable. Malleable lead wire, lead piping, lead wool and, for light pressures in good ground, cement are efficient substitutes.

It is a wise precaution, especially with pipes of large diameter—40 in. and upwards—to lay them, however good the ground on a thin bed, between joint holes, of concrete. This ensures even support along at least half the pipe length and reduces, if nothing else, risk of joint trouble.

The Relation of Run-Off to Rainfall.

By Herbert Lapworth, D.Sc., M.Inst.C.E.

The relation of run-off to rainfall has not received in Britain the systematic and scientific study that has been devoted to it on the Continent and in the United States of America. The problem is extremely complex, and unfortunately, though much data has been published of late years in regard to the flow of British streams, the accuracy of some of the figures is open to question. The chief factors that influence the flow of streams, in addition to the rainfall itself, appear to be the geology and topography of the gathering ground. Other factors of apparently less importance are the mean annual temperature, the area of the gathering ground, and the character and extent of the vegetation.

The Mean Annual Loss (Evaporation).—A study of 29 different streams in Britain yields the result that the mean annual loss (evaporation) may range from minus 2 in. (or gain) to 28 in., the average being a little over 14 in., while 18 out of the 29 observations show average losses between 11 in. and 17 in.

According to Penck, Vermeule, à Morley Parker and others, the evaporation from land surfaces increases with increase of rainfall, both regionally and in the same watershed. While our British records are too uncertain and variable to enable one to trace this regional law, it certainly appears to hold good in individual British streams. According to Penck in Germany, and Vermeule in America, the mean annual evaporation increases by about $\frac{1}{5}$ in. for each degree (F.) increase in the mean annual temperature. The influence of vegetation (especially in regard to forests) on rainfall, evaporation and stream flow regimen is still a vexed question; and the evidence from different countries and localities is contradictory.

The Monthly Flow.—While the laws of annual loss in streams in relation to rainfall are difficult enough to trace, the problems of seasonal and monthly flows are infinitely more complex, due chiefly to the effect of ground water storage, the amount of which is dependent mainly upon geological conditions.

It is now generally recognised among hydrologists that no investigation of stream flow regimen can be satisfactory unless this factor of ground-water storage be taken into account. The normal regimen of a stream is usually very different from that in the driest years, and assumptions that the distribution of flow in such years will be similar, or that the monthly losses will be identical with those in normal years, may be seriously misleading. Owing to the dual nature of stream-flow, that is, a surface of flood-flow superimposed as it were upon a discharge of ground water, it would seem that casual stream-gauging, unless covering a fairly dry year, is apt to be of less real value to the water engineer than is usually supposed, except in so far as the average annual loss and the average dry-weather flow is concerned. Much purely scientific work is still required in the analysis of stream-gaugings in relation to rainfall and evaporation. In this connection observations from soil-evaporation tanks erected in the actual gathering-grounds may prove helpful.

The Dry-Weather Flow.—The dry-weather flow, or spring flow, is derived, of course, almost solely from ground-water storage, and is a factor of the greatest importance, both in relation to questions of reservoir storage or the utilisation without storage of streams for water-power or water supply.

The extreme dry-weather flows in this country appear to range from zero in very small gathering-grounds and areas of low rainfall to 1 or more cu-secs per 1,000 acres in areas of pervious rocks or of high rainfall. In relatively impervious gathering-grounds with average annual rainfalls of between 40 in. and 50 in., the extreme dry-weather flow is generally found to lie between $\frac{1}{10}$ and $\frac{1}{4}$ cu-sec per 100 acres. The dry-weather discharge is naturally dependent upon the geology of the gathering ground, being higher in areas of pervious rocks than in areas of impervious strata. Again it would seem to follow that the dry-weather flow should increase with the rainfall. This is certainly the case in individual gathering grounds, though when we study the minimum summer flows from many different watersheds in relation to the average rainfall, no obvious connection is apparent. Nevertheless, if the records are considered in groups it will be seen that there is marked average increase with the higher mean rainfalls. The area of the gathering ground, again, is a factor, which, though of less importance, may have to be taken into account.

Floods.—The maximum rates of flood discharge appear universally to have no relation to the mean rainfall, and in Britain our heaviest storms and floods appear to take place in our areas of least rainfall rather than the reverse, as, for example, the floods of Norwich, Bourton and Louth in recent years. For reasons which are well understood, the maximum rate of flood discharge is dependent mainly upon the size of the gathering-ground, and in practically all flood formulæ this is included as the chief and in most as the sole factor.

For British upland impervious gathering grounds the late Mr. P. à Morley Parker recently proposed the formula

$$Q = 500\ M^{\cdot\frac{4}{5}}$$

where Q = rate of maximum flood discharge in cu-secs.
M = area of gathering-ground in square miles.

This appears to agree well with actual records from areas of several thousand acres, but there appears a dearth of flood data from small gathering-grounds of 1,000 acres or so.

Information Chiefly Required.—It is in records of stream flows from areas of high rainfall—that is, 100 in. or more mean annual rainfall—that we appear to be lacking, and in a lesser degree in those from areas of low rainfall, that is, below 30 in. Records of the former class of stream especially would throw much light upon the laws of evaporation and dry-weather flow, and enable us to determine with more certainty the laws governing reservoir storage. In addition scientific analysis of reliable stream-gaugings, in relation to rainfall, is greatly needed. This is not necessarily the work of the water engineer, but might be taken up by the meteorologist, physicist or mathematician.

Compensation Water.

By Edward Sandeman, M.Inst.C.E.

The subject of compensation water is one which has exceptional interest at the present time, when the necessity for the economical provision of water and for making the greatest possible use of all available supplies is of more importance than was formerly the case, owing to the excessive cost of the construction of new works.

Practically all the large undertakings constructed for the supply of water by gravitation during the last sixty or seventy years have only been granted their statutory powers to take lands and streams and construct waterworks on condition that compensation water should be given to the streams affected, either by a constant or intermittent flow. In some cases the riparian owners have agreed to accept a monetary payment in respect of the damage done to their lands and property by the abstraction of the water which they were entitled to use. The cost of making provision for the supply of compensation water bulks largely in estimates for new works, and in particular is it heavy in cases where it is necessary to make a separate reservoir solely for this purpose.

The quantity of compensation water to be given is fixed by Parliamentary Committees as a proportionate part of the average quantity of water available from the watershed in each of the three driest consecutive years. The average rainfall in each of these years is found by taking 80 per cent. of the mean rainfall on the watershed. From this quantity a further deduction is made for evaporation losses, the remainder being the available rainfall, or the average quantity of water running off the watershed in each of the three dry years.

The following table gives instances of the variation in the proportion of compensation water to available water as fixed by Parliament in respect of a number of watersheds with differing rainfalls:—

Table I.—*Data as to Compensation Water.*

	Authorised.	Assumed Average Rainfall.	Available Rainfall in 3 Dry Years.	Water for Compensation.	Proportion of Compensation Water to Available Rainfall.	Area of Water-Shed.
		in.	in.	in.	per cent.	acres
Thirlmere (Manchester)	1879	100	72·0	9·0	12·5	10,800
Loch Katrine (Glasgow) ..	1855	74	45·2	15·0	33·3	46,400
Elan (Birmingham) ..	1892	69	36·0	9·0	27·5	44,000
Vyrnwy (Liverpool)	1880	61	36·9	9·0	27·0	22,000
Dunsop (Blackburn)	1877	—	27·0	9·0	33·3	6,800
Alwen (Birkenhead) ..	1907	52	27·6	9·2	33·3	6,300
Derwent Valley	1899	47	23·4	7·8	33·3	32,000
Weardale ..	1866	30	10·0	3·25	32·5	6,000

The Loch Katrine compensation water, which is equivalent to 15 in. of rainfall, is the largest quantity, so far as the writer is aware, given by Parliament in respect of any watershed.

It will be observed that the greatest proportion of compensation water is one-third and the smallest one-eighth of the available rainfall, and that the latter amount was fixed in the case of the watershed of Lake Thirlmere where the rainfall was estimated to be on the average 100 in. There have been cases in which as much as one-half the available rainfall has been given to the river, but these have not been included in the table, since they are of older standing, and are not likely to form precedents in the future.

When the Thirlmere scheme was before a Parliamentary Committee it was pointed out by the late Mr. J. F. La Trobe Bateman that it had become usual in regard to watersheds in the Pennine Range, where the available rainfall is from 24 in. to 30 in., to give one-third part of this available water as compensation water, *i.e.*, from 8 in. to 10 in., as that amount had been found satisfactory to mill owners; but that such a proportion would be wasteful and unnecessary with a considerably higher rainfall.

It would appear not unreasonable, that when the quantity of compensation water is being fixed, some regard should be had to the natural flow of the river in dry periods, and in order to illustrate the way in which river flows have been increased by compensation water, the following table has been prepared:—

Table II.—*Comparison of Compensation Water with Dry Weather Flow.*

	Compensation Water.	Dry Weather Flow.				Proportion of Compensation Water to Dry Weather Flow of		
		1 Day.	1 Week.	1 Month.	Cubic Feet per Second per 1,000 Acres Basis of 1 Week.	1 Day.	1 Week.	1 Month.
	Million Galls. per Day.							
Elan ..	27·0	4·0	—	—	—	6·75	—	—
Vyrnwy ..	13·5	2·4	2·54	3·9	0·214	5·6	5·3	3·5
Dunsop ..	3·8*	1·8	1·9	2·2	0·59	2·1	2·0	1·7
Alwen ..	3·6	0·19	0·26	0·47	0·076	19·0	14·0	7·7
Derwent Valley	15·2	5·0	6·0	7·6	0·348	3·0	2·5	2·0
Weardale	1·22	—	0·16	—	0·05	—	7·5	—

* Corporation gave money payment in respect of 2½ million gallons per day, reducing this quantity to 1·35 million gallons.

In drawing a comparison between the dry weather flow of a stream and compensation water it is necessary first to define over what period the dry weather flow shall be reckoned. Figures are given in Table II.—where they were obtainable—for 1 day, 1 week, and 1 month, and it is suggested that to take a basis of comparison of 1 week is not unreasonable.

On referring to the last column of Table II, it will be observed that the compensation water given to the River Alwen is—on the basis of 1 week's average flow—equal to fourteen times the former normal flow of the river. In other cases it varies from 7·5 times down to twice the normal flow in the driest week. It is necessary, of course, in order to make a proper comparison, to take into consideration the actual dry weather flow per unit of area, which, it will be seen, varies greatly in the instances given. If a fixed dry weather flow of 0·2 cub. ft. per second per 1,000 acres be assumed in each case, the proportions of compensation water to dry weather flow become: Elan, 5·7; Vyrnwy, 5·7; Dunsop, 5·8; Alwen, 5·2; Derwent Valley, 4·4; Weardale, 1·9.

Having regard to these results the author is of opinion that, excepting in areas where water is required for manufacturing trade or special purposes, there is no necessity in many cases to increase the river flow to so large a figure as has been customary in the past.

Within the limits of this paper it is impossible to cover all the ground connected with the subject, but there are two other points which might effect economy in future works, and these are: (*a*) Statutory provision for the purchase of compensation water during the winter months, or when the flow in rivers exceeds a certain figure. (*b*) Parliamentary licence to take water from rivers for a certain specified period or periods without giving compensation water.

SECTION VII.—ELECTRICITY WORKS AND POWER TRANSMISSION.

Battery Locomotives.

By James Dalziel.

Electric shunting locomotives may be either operated from overhead wires or from a self-contained battery. Certain limitations imposed by the battery roughly define the respective spheres. Generally speaking, battery operation is most suitable for yards where the work is moderate and fairly uniform, especially where fairly long lengths of infrequently worked siding are involved. In such cases battery locomotives will economically replace horse or capstan shunting. A probable field for battery traction on electrified main lines is that of working way-side sidings with a battery tender to supply the main line locomotive. Some branch lines may be worked economically with battery locomotives. Shunting in large goods yards will probably be best effected by locomotives combining overhead conductor with battery supply, the battery dealing with the lightly worked sidings. Where the obstruction of an overhead wire is objectionable, as on quay sides, battery operation is the only form of electric traction possible.

Supply by battery alters for the worse the operating characteristics of an electric locomotive, especially as regards overload capacity. Straight battery working is not suitable for heavily worked sidings, or those out of which an occasional heavy lift has to be made, and the same applies to lines having heavy gradients, or that at certain hours require specially heavy trains to be handled. In such cases overhead conductors should be used; undue increase in battery capacity and weight, or the provision of special types, prohibitively enhances costs. Mid-day boosting charges are adverse to the life of all batteries of whatever type.

Many existing sidings where locomotive operation may be contemplated are equipped with turntables. If it is, as it may be, impossible to substitute points for these, a capstan may be fitted to the locomotive, so as to enable it to pass over such turntables and into the sidings they serve.

Weight and capacity of such locomotives naturally vary in accordance with the work to be performed. A typical locomotive, which was built by the Midland Railway in 1913 to supersede horse shunting in a London coal yard, has the following dimensions:—

Weight	... ...	17 tons 7 cwts.
Draw-bar pull	...	6,400 lb., max.
Normal load	...	8 loaded wagons (90 tons).
Maximum load	...	12 wagons.
Speed	... ...	7 m.p.h.
Unloaded speed	...	about 12 m.p.h.
Yard capacity	...	about 100 wagons.
Average weight per haul	... ...	about 30 tons.
Average length of haul	... ...	about 50 yards.
Annual ton miles	...	about 45,000 (excluding locomotive weight).

Design and Construction.—Standard wagon parts can in general be used. Hand brakes are sufficient. Special attention is required to battery box ventilation and insulation. The Midland locomotive is mainly built up of 10-ton wagon parts. The brakes are screw operated, working on a special brake drum to avoid undue wear on tyre brakes owing to grit. A rheostatic brake is also regularly used.

Motors.—Motors should be wound specially for low speed and single reduction gear. The Midland locomotive motors are of 22 h.p. at 220 r.p.m., nose-suspended and spur geared 15–68.

Controller.—A single controller is fitted in the driver's cab, it being of ordinary tramway type with rheostatic brake as aforesaid.

Batteries.—Special batteries of the road vehicle type are unnecessary for rail traction. Where the use of battery in preference to conductor supply is justified, a flat plate type battery is sufficiently good for the service, and it is anticipated that battery contractors will guarantee such batteries for up to ten years at an annual charge of about 10 per cent. to 15 per cent. of first cost. On the Midland engine the battery is by the D.P. Battery Company, consisting of 108 train lighting type cells in wooden boxes lead lined, the capacity being 300 ampere hours at the 10 hour rate.

Charging.—Charging arrangements should be sufficiently automatic to enable technically unskilled labour to be normally employed. In the Midland case charging is done from the Corporation mains through a motor generator; the generator is wound with shunt and reverse series coils, so that the maximum voltage that can be impressed on the battery is about 2·6 per cell with 10 amperes only passing, while with 70 amperes passing the voltage becomes only 2·1 volts per cell. The shunt coil can be adjusted by field regulation, so as to bring up the voltage to 2·7 per cell for gassing charges, which are given periodically under skilled technical supervision.

Working.—In a self-contained yard such engines can be driven by yard staff, who can also perform other duties. If the engine has to work on to or across the main line a qualified driver would have to be employed.

Operating results.—The energy consumption of battery locomotives is necessarily high, the actual consumption varying according to the nature of the service. In addition to the normal losses by frequent stops and braking, there are the special losses in the battery and charging plant. In the Midland case the energy consumption measured at the Corporation meter averages about 100 watt hours per ton mile. The over-all efficiency is about 50 per cent., *i.e.*, a battery locomotive consumes about double the energy of a conductor-supplied locomotive on the same work. On the other hand, rail bonding in yards presents some difficulties; moreover, in most cases an earthed return is not permissible; motor generator losses are thus inevitable unless double overhead wires are used.

Costs.—A locomotive of the type and capacity shown would cost, pre-war, approximately, £900, with, say, about £200 additional for charging plant.

This locomotive replaced five horses and four men pre-war, the annual value of which, at to-day's prices, is about £1,600. The working cost of the locomotive for the year 1920 was about £400; adding provision for battery renewal, interest, and depreciation at to-day's prices and rates, the total cost amounts to about £800, so that in similar conditions such an engine could be installed to-day to save £800 per annum over horse shunting.

CATALOGUES.

Lifting Trucks.—Messrs. Herbert Morris, Limited, Loughborough, send a special booklet catalogue of their lifting trucks.

Collapsing Taps.—A useful little handbook has been issued by Messrs. Alfred Herbert, Limited, Coventry, giving full information as to the construction, operation and sharpening of their collapsing taps.

Roller Bearings.—Roller bearing units for countershafts and loose pulleys, from 1¼ in. to 3 in. shafts, are listed in a special catalogue issued by Messrs. Hyatt, Limited, Thurloe-place, London, S.W. 7.

Switch Gear.—The Electrical Apparatus Company, Limited, South Lambeth-road, London, S.W. 8, send a catalogue of draw-out pillars and switchboards especially suitable for mining and industrial service.

Miniature Rifles.—A description of the factory and process of manufacture of 0·22-in. match rifles has been published in pamphlet form by B.S.A. Guns, Limited, Birmingham.

Aluminium Bus-Bars.—A catalogue giving practical information on aluminium bus-bars and connections has been issued by the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4.

Evaporators.—Evaporators for converting sea-water into fresh water, for boiler feed, drinking and cooking purposes, are described in a new catalogue issued by the Griscom-Russell Company, 90, West-street, New York, U.S.A.

Fibre Goods.—A variety of joints, washers, handles, and many small mechanical parts, made from a strong fibre is illustrated in a catalogue received from Messrs. Spauldings, Limited, 40, Gloucester-street, Clerkenwell, London, E.C.

Motor Car Engine Starter.—A catalogue describing a simple and inexpensive impulse starter for motor car engines comes from Messrs. Brown Brothers, Limited, Great Eastern-street, London, E.C. 2. This device involves the use of the ordinary starting handle.

Street Lamps.—Electric street lanterns fitted with reflectors which throw the light along the street, instead of over a circular area, are described in a catalogue issued by the General Electric Company, Limited, Kingsway, London, W.C. 2.

Coil Winding Machines.—Machines for winding electromagnet coils by cross-wind and concentric-wind methods are described in a catalogue received from the Igranic Electric Company, Limited, 147, Queen Victoria-street, London, E.C. 4.

Turbo-Alternators.—An explanatory catalogue of large steam turbine generating units has been issued by the Metropolitan-Vickers Company, Limited, Trafford Park, Manchester. Illustrations appear of sets supplied to the Glasgow, Manchester and Cardiff Corporations.

Float Switches.—Float switches for starting small alternating current motors up to 5 h.p. and smaller direct-current motors, are described in a leaflet received from the Electrical Apparatus Company, Limited, South Lambeth-road, London, S.W. 8.

Electric Welding.—An electric machine for low-tension alternating current arc welding, embodying a regulator which can be easily set within the required limits, is described in a catalogue issued by Daysohms, Limited, 14, Cockspur-street, London, S.W. 1. We described the device on page 562 of our issue of May 6 last.

Gas Exhausters.—A catalogue showing an extensive range of gas exhausters driven by gas and steam engines comes from the Bryan Donkin Company, Limited, Chesterfield. The various auxiliary machines and instruments cover nearly all requirements for distributing gas to distant places and transforming pressures to suit transmission and local needs.

Speed Indicators.—Speed indicators for indicating either surface speed in feet or revolutions per minute, and in forms for hand application to a revolving surface or belt drive, are described in catalogues received from Engineering and Colliery Appliances, Limited, Sheffield. The hand instrument is offered as suitable for turners.

Concrete Structures.—Messrs. Simon Carves, Limited, 20, Mount-street, Manchester, send a catalogue containing many impressive illustrations of industrial buildings in reinforced concrete, designed and erected by them during recent years.

Steel Buildings.—A catalogue of steel and composite buildings, ranging from large hangars to small sheds, and also roofs, light bridges, stairways and other parts, comes from Messrs. Boulton and Paul, Limited, Norwich, who erect each building at their works and then ship it in parts for re-erection either at home or abroad. Some excellent examples of work done are illustrated.

Locomotives.—It is by no means easy to write an instruction book for operators of machinery, but the staff of Messrs. Andrew Barclay Sons and Co., Limited, Kilmarnock, have carried out the task very efficiently in a little pocket instruction book for the use of drivers of small locomotives. The man who aspires to run a small locomotive and keep it in good working order will get some useful help from this little book.

Electric Motors.—The catalogue of small dynamos and motors issued by Agricultural and General Engineers, Limited, Central House, Kingsway, London, W.C. 2, is one of the most comprehensive of its kind. The machines listed range from ½ h.p. to over 5 h.p., and the descriptions, illustrations and commercial particulars are fully and clearly stated. A variety of supplementary and spare gear is dealt with in the catalogue.

Ram Pumps.—Three-throw ram pumps of the horizontal type, driven by electric motors, are the subject of a special catalogue received from the Uakside Engineering Company, Limited, Newport, Mon. These pumps are for high lifts and heavy continuous service, such as are required for colliery work, and the parts are made to standards so as to be easily renewable. The range of sizes listed is suitable for all general requirements.

Copper Boiler Tubes.—Some very cogent reasons to justify the extra expense of copper boiler tubes, and much useful information on the subject, are given in a pamphlet issued by the Brass and Copper Tube Association, Edmund-street, Birmingham. It seems, however, hardly necessary to complicate the calculations by introducing the element of compound interest on the respective costs of steel and copper.

Air Compressors.—Messrs. Reavell and Co., Limited, Ipswich, send a catalogue of their one-stage and two-stage axial type air compressors for small capacities. The one-stage compressor is suitable for pressures up to 60 lb. per square inch, and is made in eight sizes, displacing from 3·6 cub. ft. to 127 cub. ft. of air per minute. The two-stage compressor is suitable for pressures up to 250 lb. per square inch, and is made in six sizes. These machines are of very simple design, are easily dismantled for examination and have ample bearing surfaces. Full particulars of each machine can be found from a few concise tables in the catalogue.

Grinding Gear Teeth.—The statements made in a booklet issued by the Gear Grinding Company, Limited, Handsworth, that the motor-car gear-box is much the same in design and method of production as it always has been, and that the main castings can be distorted almost with the pressure of the fingers, are hardly correct. The improvements made are considerable, and highly efficient gears are the rule. There is, however, a good deal to be said for grinding the teeth, &c., after hardening, which process is carried out by the firm. Some very sound advice on the general design of gear boxes is given in the booklet.

Oil Engines.—A catalogue of oil engines of the horizontal fixed type, starting cold on compressed air and fed with the positive pump injection of fuel, comes from Messrs. Ruston and Hornsby, Limited, Lincoln. The powers listed are 11, ranging from 15 b.h.p. to 170 b.h.p. in single-cylinder engines, and from 100 b.h.p. to 340 b.h.p. in two-cylinder engines. These are maximum working loads, the normal and more economical loads being about 10 per cent. less. The consumption of fuel oil per brake horse-power per hour ranges from 0·48 lb. in small engines to 0·42 lb. in large engines. The description of working parts and the commercial information given is complete and concisely stated, as is usual in this firm's catalogues.

Motor Tug "Rocott."—The Rocott, a Thames motor tug, built to the order of Messrs. A. J. Humphrey and Henry Grey, Junior, Limited, tug and lighterage contractors, to the builders' design, was launched at the Faversham shipyard on the 7th inst. This tug, a sister ship to the Flanchford, which is now undergoing her trials, and which was also constructed by Messrs. James Pollock, Sons and Co., Limited, for the same owners, is 75 ft. long overall, her breadth moulded is 16 ft. 3 in., and her draught aft 8 ft. 8 in. She is to be propelled by a 350 b.h.p., four-cylinder model "N.E. 11," direct reversible heavy oil marine engine, of Messrs. Bolinder's latest design. The Flanchford is fitted with the "M" type. The auxiliary machinery includes a Bolinder stationary vertical engine for driving a Gwynnes' salvage pump capable of throwing a jet 44 ft. high, with a capacity of 40 gallons to 50 gallons per minute, a two-stage air compressor, and a generator set to supply current for mast head lights, sidelights, cabins and engine-room. She is fitted with the usual towing hooks, hand winch, and lowering funnel and mast. This launch, as usual, was broadside on.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in Italics.

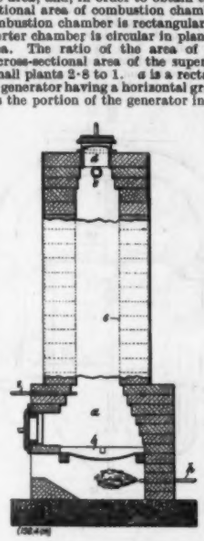
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

158,409. T. H. White, Newport. Producer Gas Plant. (2 *Figs.*) November 14, 1919.—This invention relates to a vertical gas generator for producer gas plants. In the gas generator, according to this invention, an ordinary horizontal grate is employed, thus retaining a grate which tends to preserve its designed effective area, and, in order to obtain the most efficient ratio of cross-sectional area of combustion chamber to converter chamber, the combustion chamber is rectangular in plan and the superposed converter chamber is circular in plan and of appreciably smaller area. The ratio of the area of the combustion chamber to the cross-sectional area of the superposed converter chamber is for small plants 2·8 to 1. *a* is a rectangular chamber at the base of the generator having a horizontal grate of fire bars *b*. The chamber *a* is the portion of the generator in which complete



combustion of the fuel on the grate takes place. The chamber *a* converges upwards to merge into a superposed cylindrical chamber or shaft *c* of considerably less area, wherein a column of fuel is maintained through a covered charging aperture *d*. The chamber *c* is the reduction or conversion portion of the generator. *e* is a pipe leading from the top of the cylindrical shaft *c*, wherein a suction is maintained in the known manner by steam to withdraw the generated gas along an ejector pipe. By virtue of the eductive action of the steam in the pipe *e*, the quantity of steam admitted to the column of fuel need only be such as is required for the formation of semi-water gas, and not for the production of a draught through the generator. The underside of the grate can thus be opened or left open for pricking up at all times. The steam is admitted to the fuel by a pipe *h* beneath the grate *b*, or by a pipe *i* above the grate. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

160,500. W. G. Tipson, Harrow. Automatic Screw Machines. (5 *Figs.*) November 24, 1919.—The invention refers to improvements in cam drums for automatic screw-cutting machines of the type in which the drum has a series of T-slots 2 on its outer face arranged transversely to its axis. It is provided with a slot 3 on the inner face of the drum passing through the T-slots through which the nuts of the cam-bolts are passed into said T-slots to retain the profile cams in the desired position. The slot 3 extends through the full width of the drum, as shown in dotted lines. The profile cams 4

Fig. 1.

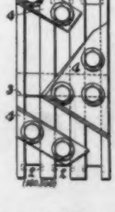
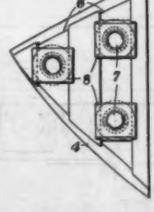


Fig. 2.



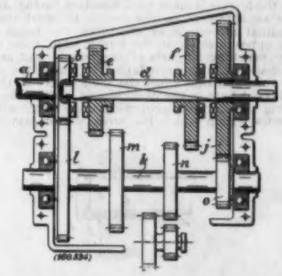
are cut to the desired form from a cylinder which has been bored to form a tight fit over the cam drum. These cams are provided with a series of tenons 6 on their under sides corresponding in width and distance apart with the T-slots 2. A series of bolt holes is bored through the cams and their tenons in such positions as to register with the T-slots 2 when the cams are in position on the drum face. The bolts 7, which are passed through these bolt holes, are fastened by means of nuts 8 which are curved to register with the inner face of the cam drum. These nuts 8 are passed into position to the desired T-slots through the transverse slot 3 on the inner face of the drum. (*Sealed.*)

160,701. S. Petts, South Darley, and W. Doxey, Rowsley. Forming Shanks of Drills. (6 *Figs.*) June 11, 1920.—The bottom die member *a* has a cup-shaped recess countersunk at its lower end and a longitudinal hole. The lower end of the member is reduced at a^3 and formed with a shoulder to enable it to be fixed in a bed. The top tool *b* has an outside diameter which will admit of it conveniently and readily entering the recess in the die *a*. The lower end of the tool is formed with a longitudinal hole of square cross-section. The bar *c* to be treated has

one end heated and then passed through the hole in the bottom die member until it projects within the cup-shaped recess. The bar *c* is firmly held in position, and the top tool *b* is brought down with considerable force upon the upper end of the bar, and enters the recess in the die *a*. When the top tool *b* has gone down a certain predetermined distance, the hole is wholly filled with the heated end of the bar *c*, and the remainder of the material of the bar within the recess is spread out and occupies the bottom end of the recess below the lower end of the top tool *b*. (*Sealed.*)

MOTOR ROAD VEHICLES.

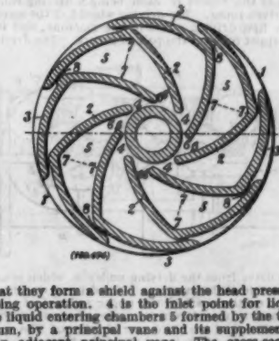
160,534. P. Gregoire, Chingford. Transmission Gearing. (1 *Fig.*) December 19, 1919.—In multi-speed transmission gearing, in which a lay shaft *k* carries two fast gears *l*, *o* in constant mesh respectively with a fast gear *b* on the driving shaft *a* and a loose gear *j* on the driven shaft *d*, which is mounted in line with the driving shaft, intermediate gears and clutches are provided for making the various driving connections. The intermediate



gears *m*, *n* mounted on the lay shaft *k* are fixed thereto, while two separately sliding gears *e*, *f* are mounted on the driven shaft *d*. The first speed is obtained by clutching the pinion *f* to the gear wheel *j*; the second speed by engaging pinion *f* with gear wheel *n*; the third speed by engaging the pinion *e* with the gear wheel *m*, and the fourth and highest speed by clutching the pinion *e* to the pinion *b*. (*Sealed.*)

PUMPS.

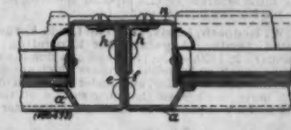
160,474. J. Wareing, Rochdale, and A. Hill, Rochdale. Centrifugal Pump. (4 *Figs.*) August 1, 1919.—Upon or near the outer extremity of each arc-shaped impeller vane is secured a supplementary vane of arc shape, the chord of such are being approximately at right angles to the chord of the arc of the principal vane, this angle varying however according to the number of impeller chambers in the drum. 1, 1 are the discs of the impeller drum, on which are cast the vanes 2; 3, 3 are supplementary vanes attached to the principal vanes, approximately at the angle shown. The position of these supplementary vanes



is such that they form a shield against the head pressure during the pumping operation. 4 is the inlet point for liquid to the pump, the liquid entering chambers 5 formed by the two discs 1 of the drum, by a principal vane and its supplementary vane, and by an adjacent principal vane. The cross-sectional area of each chamber 5 increases from the point 6-6 to the point 7-7, where it is greatest, and from 7-7 it diminishes to the outlet 8. Liquid entering at 7-7 to any of the chambers has its kinetic flow transformed into pressure on its passage from point 7-7 to the outlet 8, where the liquid emerges under the head pressure. (*Accepted April* 6, 1921.)

RAILWAYS AND TRAMWAYS.

160,473. The Metropolitan Carriage, Wagon and Finance Company, Limited, Birmingham, and L. Chandler, Birmingham. Railway Coaches. (5 *Figs.*) April 30, 1920.—In steel coaches in which the main walls of the coach are formed of inwardly-flanged panels united together by intermediate T-irons, the flanges *e*, *f* of adjacent panels *c*, *a* are brought together, and angle members *h*, *h* are secured back to back on each side of the panel flanges. A pillar *n* of channel section is secured over the angle members *h*, *h*, and encloses the connection on the interior of the coach and forms a convenient means for attaching the finish or mouldings. Instead of the angle members, a T-



section member may be employed between the flanges of the panels with a make-up piece or protecting strip between the end of the stem of the T and the exterior of the panels. (*Sealed.*)

158,378. The Railway Key-Locking Device Company, Limited, Buxton, and H. Frood, Buxton. Securing Keys. (3 *Figs.*) November 6, 1919.—The improvements relate to means of securing railway chair keys of the kind comprising a spring packing-piece capable of being inserted between one of the jaws of the chair and the usual wood key. The side of the packing-piece next the key is formed with serrations or teeth, which, on the key being driven between the rail and packing-piece bear against the key and thereby hold the key securely in position. According to the invention, the packing-piece, which is made of spring metal, is of rectangular outline with its main length arched and its ends bent almost at right angles to the main length. The packing-

Fig. 2.

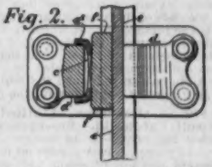
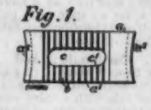


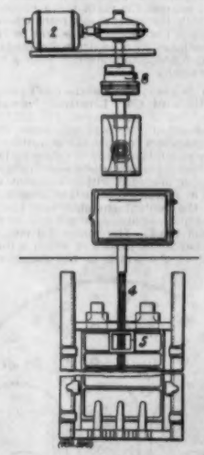
Fig. 1.



piece *a* is made of spring metal, of rectangular outline with its mid-portion a^1 arched and its ends a^2 bent almost at right angles to the portion a^1, the end flanges a^3 being slightly curved transversely. The front face of the part a^1 is formed with serrations or teeth *b* similar to ratchet teeth. An elongated slot *c* is formed in the part a^1, the edges c^1 of which are also serrated. The packing-piece is inserted edge-on between the jaw of the rail chair *d* and the rail *e*, the bent ends a^2 of the packing-piece lying against the end faces of the rail chair. The usual wood key *f* is then driven between the rail *e* and packing-piece *a* until the key lies in the correct position relatively to the chair, jaw and rail. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

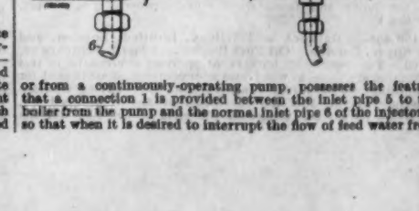
160,396. Scotts' Shipbuilding and Engineering Company, Limited, Greenock, and A. Ross, Greenock. Bulkhead Doors. (1 *Fig.*) January 7, 1920.—In operating gear for actuating ships' bulkhead doors of the type including an electric motor 2, a screw- and nut-mechanism 4, 5 connected to



the bulkhead door, and a clutch 8 interposed between the motor and the screw-and-nut mechanism, the clutch is of the electro-magnetic type and its operating coil is interconnected as a shunt to the armature of the driving motor in such wise that the clutch becomes operative when the motor has attained a predetermined speed, *e.g.*, half speed. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

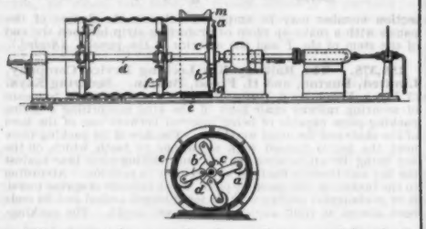
160,489. J. Fuller, Liverpool. Steam Boiler Feed Apparatus. (2 *Figs.*) October 15, 1919.—A feed water apparatus for steam boilers of portable and traction engines or the like in which water can be fed to the boiler from an injector



or from a continuously-operating pump, possesses the feature that a connection 1 is provided between the inlet pipe 5 to the boiler from the pump and the normal inlet pipe 6 of the injector 7, so that when it is desired to interrupt the flow of feed water from

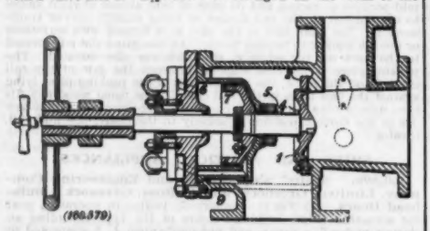
the pump to the boiler, this can be diverted to the normal inlet pipe 6 for the injector and flow back through this (when the injector is out of operation) to the supply tank, thereby avoiding the necessity for a separate return pipe for the feed, pump and serving to maintain the injector cool. *(Sealed.)*

160,585. W. Redpath, Leeds, and The Leeds Forge Company, Limited, Leeds. Apparatus for Expanding Tubes. (3 *Figs.*) January 2, 1920.—The plain end of a flue is subjected to an expanding operation by means of rollers which are caused to revolve around the axis of the flue, and, under the action of centrifugal force, to move out against the inner surface of the plain end, which is thereby expanded to the desired diameter. The



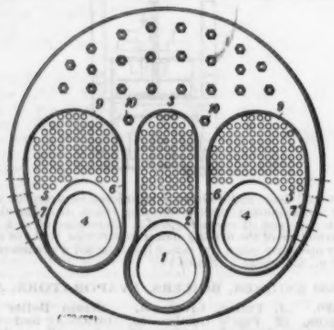
centrifugal expander comprises four rollers *a* revolving freely about the ends of the swinging arms *b* carried by a hub *c* upon a shaft *d*. The furnace flue, of which the end *e* is to be shaped, is centralised relatively to the shaft *d* by self-centring chucks *f* mounted loosely on the latter. The shaft *d* is driven by a motor. The end *e* of the flue is expanded into a die *m*, split at a point where it can be clamped, until the required expansion has taken place and it is desired to remove the flue. *(Sealed.)*

160,579. Cockburns, Limited, Cardonald, and D. MacNicoll, Cardonald. Emergency Stop Valves. (2 *Figs.*) December 29, 1919.—In an emergency steam stop valve, the main valve proper 1 can engage on one side with a valve seat 2 to intercept the flow of steam and on the other side is formed with a valve face 4. A piston 7 is arranged on the stem of the



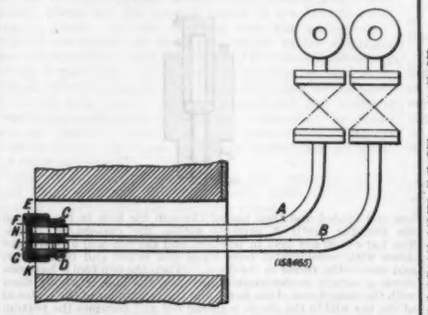
main valve proper, and is contained in a chamber 6. The end of the chamber 6 nearest the main valve proper is formed with a seating 5 on which the valve face 4 rests when the main valve proper is unseated. The passage of steam to the chamber 6 is controlled. A continuously open drain 9 extends from the underside of the piston 7 and communicates with a reserve feed tank or condenser. *(Sealed.)*

158,476. A. S. Wyber, Newcastle-on-Tyne, and R. and W. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne. Marine Boilers. (2 *Figs.*) April 12, 1920.—The invention refers to the combustion chambers of marine and other boilers. The combustion chambers constructed according to the invention are of the kind in which the heads are substantially semi-circular in form, and the invention comprises essentially a narrow central combustion chamber provided with a substantially semi-circular head, and a pair of broader combustion chambers, arranged one on each side of the central chamber and provided with substantially semi-circular heads of larger radius than that of the central combustion head. The centre furnace 1 has a narrow combustion chamber 2, the head 3 of which is formed to a radius equal to one-half of the width of the combustion chamber 2.



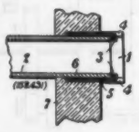
Upon each side of the central furnace 1 is arranged a furnace 4, having a broad combustion chamber 5. The inner sides 6 of these combustion chambers 5 are substantially vertical and parallel to the sides of the central combustion chamber 2, whilst the outer sides 7 are curved and conform substantially to the shape of the boiler shell. The heads 9 of these outer combustion chambers 5 are formed to a radius equal to half the width of the combustion chambers 5 at their upper ends so that the top of the combustion chambers are semi-circular in section. The tops of the heads 9 of the outer combustion chambers 5 and the head 3 of the inner combustion chamber 2 are all arranged substantially on the same level and additional boiler stays 10 are arranged in the spaces between the radial heads 9 and 3 of the outer and inner combustion chambers respectively. *(Sealed.)*

158,465. Babcock and Wilcox, Limited, London, and A. Spyer, London. Oil Fuel Burner. (4 *Figs.*) February 28, 1920.—The liquid fuel burners or sprayers referred to in this invention are those in which steam or compressed air is used for atomising. The burner consists of a body having separate passages for the fuel and the steam or the compressed air, to which burner are connected the ends of the fuel and the steam or the compressed air pipes. Against the outer face of the burner body is held by means of a screw-threaded cap, a removable plate provided with slots isolated from one another and serving for the passage of the fuel and of the steam or compressed air, respectively. By interchange of one slotted plate for a plate with slots of different sizes an increased or reduced output is obtainable. There is secured to the ends of the fuel and the steam or compressed air pipes A and B, respectively, a burner C having in its body passages separated by an internal web D.



The burner C is externally threaded to receive a screw-threaded cap E, provided with a flange F, by which a removable slotted plate G is held against the end face of the burner body. The plate G is provided with slots H and I spaced apart a suitable distance, the width of the external web of the burner C being determined to suit, such slots serving for the passage of the fuel and of the steam or the compressed air, respectively. A grub screw K serves to restrain the plate G against movement relatively to the face of the burner body. *(Sealed.)*

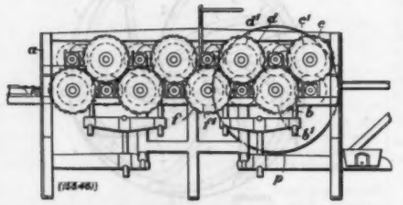
158,431. W. D. Connolly, Liverpool. Condenser Ferrules. (4 *Figs.*) November 25, 1919.—According to the invention, the ferrule is made from standard tubing, and in order to provide an abutment on the ferrule to resist the tendency of longitudinal movement of the tubes, two tangs are turned in, and at opposite sides, at the ferrule edge, these tangs being formed by punching in parts of the ferrule wall at the edge. These overhanging tangs are adapted to engage the edge of the condenser tube and thus effect the same object as the shoulder of the restricted bore in the usual ferrule, and at the same time by punching the inwardly-projecting tangs notches are left at opposite sides within which the screw driver may engage for



tightening up the ferrule. The ferrule 1 is made from standard tubing, and an abutment is provided on the ferrule to resist any tendency of longitudinal movement of the tubes 2 by stamping inwardly, and at opposite sides of the ferrule edge, tangs 3. These overhanging tangs 3 engage the edge of the condenser tube and prevent end movement of the latter. The metal of the tangs 3 being stamped inwardly from the edge of the ferrule notches 4 are left at opposite sides within which the tool for tightening up the ferrule may be engaged. The exterior of the ferrule tube is threaded at 5 to engage the internally-threaded gland 6 in the condenser tube plate 7. *(Sealed.)*

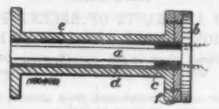
TEXTILE MACHINERY.

158,461. J. A. Williamson, Portadown. Flax-Breaking Rollers. (1 *Fig.*) February 10, 1920.—The invention relates to flax-breaking rollers. According to the invention, there is provided an arrangement of gears whereby the machine can be driven with a minimum of gear wheels so that a considerable saving in cost and a saving in power can be effected. The horizontal flax-breaking machine *a* has its pair of inter-meshing rollers driven by their under rollers and upper rollers alternately, one of the rollers of each being a driving roller and the other the driven roller. The driving wheel *b* of the second bottom roller is the first driving wheel of the machine, and its roller *b*1 drives the upper roller of the pair of rollers. The driving wheel *b*



receives its drive from the driving pulley *p*, which is arranged at the opposite side of the machine. The driving wheel *b* drives the gear wheel *c* on the shaft of the upper roller *c*1 of the first pair of rollers, and it also drives the gear wheel *d* on the shaft of the upper roller *d*1 of the third pair of rollers. The gear wheel *d* drives the gear wheel *f* on the shaft of the bottom roller *f*1 of the fourth pair of rollers and so on, the driving roller being alternately an upper roller and an under roller for each alternate pair of rollers. By this arrangement idle pinions for reversing the direction of rotation of the driving wheels are dispensed with and the machine can be driven with only half the number of driving wheels. *(Sealed.)*

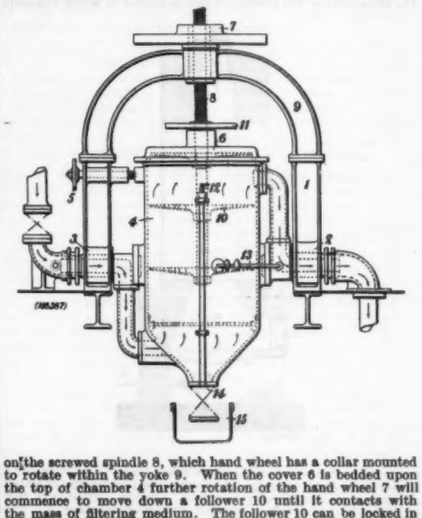
160,469. E. L. Rankin, London, and James Austin and Sons, Limited, London. Tensioning of Yarns. (3 *Figs.*) November 7, 1916.—The invention relates to the tensioning of cords and yarns during the unwinding of them from spools or coils. An electromagnet is employed consisting of an iron spindle *a* with an integral flange *b* at one end and a winding *c* connected with a source of electric current. A tube *d* is placed over the spindle to provide a bearing for the wooden spool *e*, which has a paramagnetic metal plate *f* attached by pins to one end. When the coil *c* is energised, the flange *b* becomes magnetised and attracts the plate *f* on the spool. Thus the parts *b*, *f* form a magnetic brake tending to hold the spool against rotation with more or less force, depending upon the pull of the magnet and the



friction of the contacting surfaces of the flange and plate *b*, *f*. The retarding action thus exerted can be adjusted to impart the required tension to the material being run off the spool. *(Accepted April 6, 1921.)*

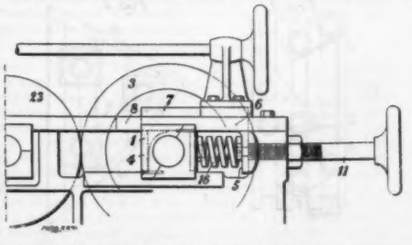
MISCELLANEOUS.

158,387. J. Miller, Derby, and George Fletcher and Co., Limited, Derby. Filter. (1 *Fig.*) November 7, 1919.—The invention relates to a filter of the type in which the material to be filtered can pass freely through a mass of renewable filter material which may have slight pressure applied to it if desired. According to the invention, a filter chamber is carried on trunnions in a yoke which carries the cover mounted together with a follower to act on the filtering medium within the chamber, so that the thrust of the cover against the chamber and of the follower against the medium, when these are in the working position, is taken up by the yoke. A frame 1 has trunnions 2, 3 adapted to carry a pivoted filtering chamber 4 fed through the hollow trunnion 3 and exhausted through the hollow trunnion 2. A stop 5 is provided to maintain the filter chamber in its normal position of operation. In use, the filter chamber is swung about trunnions 2, 3 to receive a charge of filtering medium. It is then moved into the position shown in the drawing, and the cover 6 is lowered on to the top of the chamber 4 to close this by rotating the internally-threaded hand wheel 7 mounted



on the screwed spindle 8, which hand wheel has a collar mounted to rotate within the yoke 9. When the cover 6 is bedded upon the top of chamber 4 further rotation of the hand wheel 7 will commence to move down a follower 10 until it contacts with the mass of filtering medium. The follower 10 can be locked in this position by the hand locknut 11. The material to be filtered can then be allowed to pass into the chamber 4 through the hollow trunnion 3, so that in bringing the filter into and out of operation no pipe joints are broken. The material will filter through the chamber 4 and pass out through the hollow trunnion 2. Should the material passing through the filter become muddy, extra pressure can be applied to the filtering medium by means of the hand wheel 7, by which the follower can be moved to a position below the stop cock 13. A test cock 12 is provided on the chamber for testing the level of the liquid in it. The pipe and stop cock 13 are provided for drawing off liquor lying above the follower when in its lower position prior to emptying the chamber of its filtering medium. A stop cock 14 is provided at the base of the chamber 4 to draw off the mud into the channel 15. *(Sealed.)*

160,553. Brinjes and Goodwin, Limited, London, and C. J. Seaman, London. Roller Grinding Mills. (3 *Figs.*) December 22, 1919.—In roller grinding mills of the kind wherein at least one roller is supported in such manner that its bearings are adapted to yield against the action of resilient means on the passage of foreign material between the rollers, the front roller 3 is positively adjustable towards or away from the adjacent roller 23, without affecting the tension of the resilient means. The roller 3 is supported in bearings carried in bushes 1, arranged



to slide between flanges 4, 5 depending from a bracket 6 adapted to be displaced relatively to and guided by the frame of the mill, the bushes being displaceable independently of the bracket against the action of a spring 16 which returns the bushes 1 and consequently the roller to normal grinding position. The bracket 6 is provided with an upward projection 7 adapted to engage in a slot 8 provided in the usual frame cover. The flange 5 of the bracket is slotted to receive a screwed rod 11 carrying a hand wheel at its outer end and suitably secured against the depending flange at its inner end. *(Sealed.)*